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# SCHOOL SCIENCE AND MATHEMATICS

DECEMBER 1957

# School Science and Mathematics

*A Journal for All Science and Mathematics Teachers*

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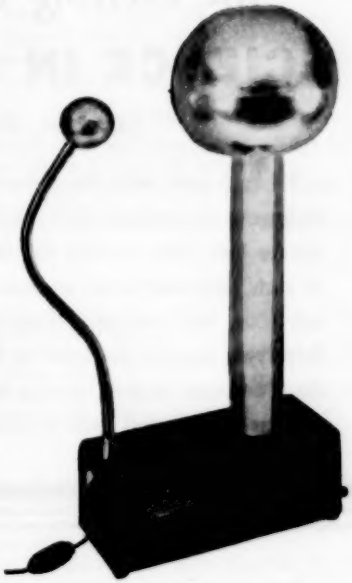

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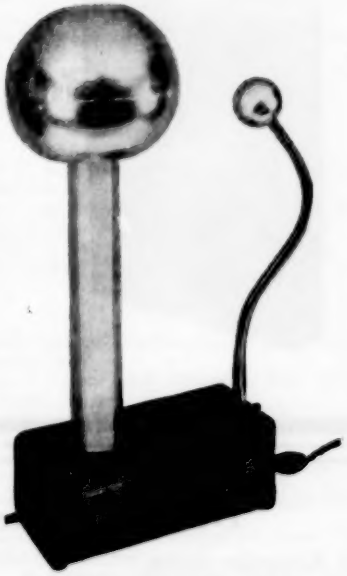

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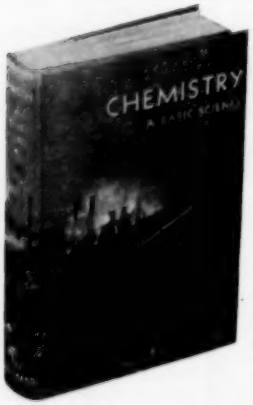


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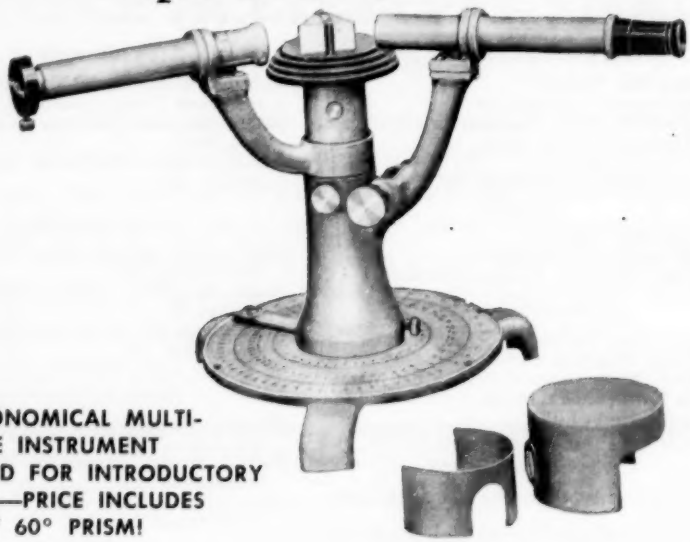

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VOL. LVII DECEMBER, 1957 WHOLE NO. 506

# EDUCATIONAL VALUES OF SCIENCE-IN-THE-NEWS

W. C. VAN DEVENTER
*Department of Biology, Western Michigan University, Kalamazoo, Michigan*

## BACKGROUND OF SCIENCE NEWS REPORTING

Although the publication of science news of a haphazard and sporadic sort dates back to the earliest history of American journalism before the War of Independence, its development was slow until the time of World War I. Even such outstanding scientific events as Fulton's steamboat, the invention of the telegraph, telephone and electric light, and the Wright brothers' flight of the first heavier-than-air machine at Kitty Hawk, were only tardily and inadequately reported. Krieghbaum (1941),[1] in his comprehensive history of science news writing, says "Science reporting before the World War (1914–1918) was a combination of editorial whim, hoax, newspaper-financed stunts, garbling and faking of details when truthful information was scarce, plus an occasional professional job well done . . . . On infrequent assignments, competent reporters were assigned to cover science news."

The first professional science news writers began their work during and immediately following World War I. It was during this period that leading newspapers began to include science editors as regular staff members. The first science news stories to be accurately and comprehensively reported were the confirmation of Einstein's Theory of Relativity by observations of a total solar eclipse in 1919, and the discovery and exploration of the tomb of Tutankhamen in 1922–1923. The first meeting of the American Association for the

[1] Krieghbaum, H., American Newspaper Reporting of Science News, *Kansas State College Bulletin*, Vol. XXV, No. 5, Industrial Journalism Series 16, Aug. 15, 1941. p. 40.

Advancement of Science to be reported by a press corps of science writers, as distinguished from local reporters, was the Cambridge, Massachusetts, meeting in 1922. In 1923 Alva Johnson of the *New York Times* was awarded the Pulitzer prize for reporting for his coverage of the Cambridge meeting. Frequent authoritative feature articles on various phases of science were carried by the *Kansas City Star* during the 1920's, and contributed significantly to the early education of the writer of this article.

E. W. Scripps, of Scripps-Howard newspapers, and founder of the Scripps Institution of Oceanography, was the prime mover in the establishment in 1921 of Science Service, the science news agency. He supported it financially in its early days and later endowed it. This organization sends out daily science releases to subscribing newspapers, written in a style that is understandable to the general reader. In 1926, Science Service began the publication of *Science News Letter* for private subscribers.

The National Association of Science Writers was organized in 1934. It has established standards for science news writing, has served as a recognized and responsible intermediate group between research scientists and the public to assure accurate reporting of science news.

## Nature of Science News Writing

Reputable present-day writers of science news are of two types: (1) Persons with scientific background who have gone into journalism, and (2) Journalists who have become interested in science, and have built up their scientific background through personal contacts, experiences and self-directed reading. Excellent science news writers are found in both categories.

For reading by the general public, science news articles must be written at a level comparable to that used generally by the periodical which publishes them. They must also be relatively self-contained. That is, they must not pre-suppose a scientific background beyond that of the general reader. They must include their own essential background information, and define much of their own terminology. Furthermore, they must maintain scientific standards of accuracy, objectivity, tentativeness and consistency.

Criteria for evaluating science news have been worked out by the Science Committee of the Cooperative Study for the Evaluation of General Education of the American Council on Education.[2] According to these criteria, periodicals publishing science news range from Sunday newspaper supplements and tabloids which may publish

[2] Dressel, Paul L., and Mayhew, Lewis B. (editors), *Science Reasoning and Understanding, A Handbook for College Teachers*, Wm. C. Brown and Company, Dubuque, Iowa, 1954. Chapter IX, Evaluation of Popular Articles in Science, pp. 180–199. The person primarily responsible for writing this chapter was Dr. Clement L. Henshaw of Colgate University.

over-glamorized exaggerations, to scientific research journals which publish only highly technical articles for the specialist. It is obvious that both the "lowest" and the "highest" levels indicated by this scale are unsuitable for use by students at the elementary, high school and junior college levels, and by non-specialized science teachers. The most valuable materials for science teaching are to be found in periodicals at the intermediate level. These may be represented by *Time, Life, Newsweek, Science Digest, Science News Letter, Scientific American* and conservative daily newspapers such as the *New York Times*. Local daily newspapers often carry a high number of valuable science news articles. The best of these are generally derived from Science Service, or carry the by-line of a professional science writer.

The criteria for evaluating science news articles, as listed by Dressel and Mayhew (1954)[3] are as follows:

Reliability is favored:

1. If the publication has a general reputation for careful, complete and accurate reporting of all news.
2. If the story is derived from an announcement at a professional scientific meeting or in a professional scientific journal.
3. If the investigation reported was conducted at a recognized university or research center, rather than by an individual working on his own.
4. If the investigation reported is based on evidence derived from repeated experiments, or confirmed by separate methods rather than being based on a single case or event.
5. If the headline is reasonably consistent with the story.
6. If the first paragraph of the story is free of lurid statements and unsupported assertions, and is consistent with the rest of the story.
7. If an effort is shown to report the *real* story by the use of quotations, or by reference to the original investigator and his work.
8. If the story is long enough to show that it was carefully prepared.
9. If the full story is reproduced, and not cut to fit available space. The last paragraph as a summary is likely to be valuable.
10. If the story is free from: (a) excessive extrapolation, and (b) phrases like "which way," used merely to create interest.

Ways in which science news writing may be unreliable:

1. The writer may fail to consider the most recent available information or investigations on the subject, or else fail to specify the limiting date for the conclusions arrived at.
2. He may mis-state some of the relevant facts.
3. He may selectively state and omit relevant facts, or introduce information of doubtful relevance, and thus bias the evidence.
4. He may state opinions or hypotheses as facts.
5. He may use fallacious reasoning from relevant facts, such as extrapolation or reasoning by analogy.
6. He may make inferences without supporting them.
7. He may present information in such a manner that the reader is led to unjustified inferences.

[3] Dressel, Paul L. and Mayhew, Lewis B., *op. cit.*, pp. 184–185. These criteria were based on suggestions by Dr. Gerald Wendt, former science editor of *Time*, and editor of *Science Illustrated*.

8. He may dwell upon the success of one point of view and gloss over its weaknesses by:
   a. Failing to mention competitive hypotheses and the evidence supporting them.
   b. Implying support for one hypothesis by refuting others.
   c. Failing to acknowledge the possibility of still other hypotheses not yet conceived.

## Science-in-the-News as an Educational Device

There are two major uses of science news in connection with education. These are (1) up-grading science teachers at the elementary, secondary and even the college level, and (2) teaching students in science classes at all levels except advanced college courses.

Most elementary teachers and many high school science teachers are inadequately trained in science. Even college teachers of science, especially those in general education courses, have inadequate backgrounds due to overspecialization. Mallinson's study of science teaching in Michigan (1955)[4] indicates that about two-thirds of all the high school biology classes in the state are taught by persons having no more than a minor in biology. Teachers of the physical sciences generally have better backgrounds, but many of even these are inadequate. Mallinson states that "it is possible that over half the classes in general science are taught by teachers whose breadth of training is insufficient to teach the course successfully, or who have little or no science background at all." Elementary teachers have generally had only the science courses required for graduation, and many lacking college degrees have not had even these.

This inadequate preparation in science becomes apparent when such teachers apply for graduate study. Even though the desired degree may be in education, most cognate courses in science are closed to them because they lack necessary prerequisites. An experiment is currently being carried on at Western Michigan University which utilizes science-in-the-news as a remedial device for teachers desiring graduate work in biology. A course called *Recent Developments in Biological Science*, based on extensive reading and evaluation of science news, is offered at the graduate level. Persons with little formal scientific background become progressively more conversant with scientific ideas and terminology as a result of the course experiences. They acquire the motivation and ability to read beyond the limits of the course, not only in newspapers and periodicals, but also in books, ultimately even those of semi-technical character. They become "self-educated" in science, in the best sense of the term. They also acquire a technique which they can apply in their own classrooms.

[4] Mallinson, George G., The Status of Science Teaching in Michigan, *Newsletter of the Michigan Science Teachers Association*, Vol. III, No. 2, June 1955

Science-in-the-news appears to be useful in teaching at the elementary, junior and senior high school, and general education college levels. Its use at each level involves variation only in subject matter selection and method of presentation. At the lower levels the criteria for selection and evaluation must be applied by the teacher. At the higher levels they can be applied, in part at least, by the students. At the early elementary level, pictures with meaningful captions, and carefully selected science news stories retold or rewritten by the teacher in language understandable by the children must necessarily largely replace unaided reading. Science news stories at all levels must be relatable to experience, actual, vicarious or imaginable, if they are to be meaningful. This is possible on a progressively broader basis with older children, adolescents and young adults.

For the student, especially at the high school and junior college levels, the use of science-in-the-news has the following definite values: (1) It gives a feeling of being vicariously "on the firing line" of scientific advance. (2) It leads to an understanding that science is a going concern, rather than simply a body of facts to be learned. (3) It helps in the realization that scientists do not have all of the answers; that there are still unknowns to be discovered and explored. (4) It contributes to an understanding of scientific attitude and methodology. (5) It emphasizes continued learning, within the course and beyond it. (6) It helps to build up and maintain an interest in science.

## Studies on the Use of Science News

Studies on the use of science-in-the-news in teaching have been concerned mostly with the high school and college levels. Most of the early studies, beginning with that of Finley and Caldwell (1923)[5], were concerned largely with the science content of newspapers and magazines. Some of the later studies, such as those of Brown (1953)[6] and Mason and Warrington (1954)[7] have been concerned with the actual use of science news in the classroom. The writer (1946)[8] utilized a study of science-in-the-news as a partial basis for the construction of a syllabus for a general education science course at Stephens College. The Science Committee of the Cooperative Study for the Evaluation of General Education of the American Council on Education[9] utilized science news articles as a basis for the construction of tests

[5] Finley, Charles W., and Caldwell, Otis W., *Biology in the Public Press*, The Lincoln School of Teachers College, Columbia University, New York, 1923.

[6] Brown, Clyde M., Science Interests of Junior College Girls as Determined by Their Readings in Current Science, *Science Education*, Vol. 37, No. 2, pp. 105–108, March 1953.

[7] Mason, John M., and Warrington, Willard G., An Experiment in Using Current Science Articles in Classroom Teaching, *Science Education*, Vol. 38, No. 4, pp. 299–304, October 1954.

[8] Van Deventer, W. C., Organization of a Basic Science Course, *Science Education*, Vol. 30, No. 4, pp. 202–206, October 1946.

[9] Dressel, Paul L. and Mayhew, Lewis B., *op. cit.*

of science reasoning and understanding, and some general suggestions as to teaching techniques. These were to be used at the junior college level. Altogether, the writer knows of twenty-six bibliographic references dealing with science-in-the-news.

The writer has used science news in teaching undergraduate classes at the junior or general education college level both at Stephens College and at Western Michigan University. This has consisted of requiring students to read science news articles and make written reports on what they have read, and also of using science news, verbally reported by students, as a basis for class discussion, integrating the news articles, wherever possible, with the core material in the course syllabus. Tests given over the science news materials and related core materials thus discussed have indicated a degree of learning and comprehension equivalent to that attained for the same core material dealt with through the use of standard laboratory and discussion techniques. Furthermore, use of the tests developed by the Science Committee of the Cooperative Study for pre- and post-testing indicated a slight but apparently significant gain in the student's ability to read and interpret science news materials.

During the summer of 1957, the writer had the opportunity of working with 12 of a group of 30 high school science teachers from the state of Michigan who had majored in one of the physical sciences as undergraduates but who were deficient or wholly lacking in the area of biological science. These were recipients of National Science Foundation Fellowships in connection with a Summer Institute for Science Teachers at Western Michigan University, and were receiving graduate credit toward master's degrees for their work.

From the beginning of the eight-week session the careful and critical reading and evaluation of science news was stressed as a means of building up a working knowledge of a weak or unfamiliar field. Complete files of recent issues of *Scientific American*, *Science News Letter*, and *Time* were made available in the laboratory. Daily reading of science news articles in the *Kalamazoo Gazette*, which publishes excellent science coverage, was encouraged. Current science news articles were discussed in class, and formed the basis for further pursuit of topics relevant to an understanding of basic biological principles and facts. The back-files of the periodicals mentioned above were used in the further study of these topics. Although a standard textbook in general college biology was in the possession of each student, it was used as a supplement and source of additional information rather than as a primary source.

The class discussions ranged from a consideration of such elementary facts as the relationship of photosynthesis and respiration in green plants, the operation of enzymes in digestion, Mendel's laws

and the body's defenses against disease, to topics such as the chemical nature of viruses and genes, the operation of metabolites and antimetabolites in living matter and the relationship of ecological succession to evolution, which might form the basis for advanced biology seminars. In the opinion of the writer, at least two-thirds of the basic biological principles listed by Washton[10] and Martin[11] as important for general biology courses at the college level were dealt with, as well as many important advanced concepts which are not usually accessible except to graduate majors. The students responded very favorably to this approach, and indicated unanimously at the completion of the project that they had found it valuable and wished that it might be continued.

In the light of these experiences it would appear that the use of science news, and its integration with core material in science courses, furnishes a useful tool in attacking some of our teaching problems. Further study is necessary, however, in (a) the evaluation and standardization of the method as used at the college and graduate levels, and (b) the development and application of workable techniques at the elementary and secondary levels.

## Summary

A modern concept of laboratory learning in science makes it desirable that certain types of reading materials be kept in the laboratory for use by the student in problem-solving operations. Important among these are newspapers and magazines containing science news. Criteria for evaluating these materials are available and may be applied by teachers and by high school and college students.

Science-in-the-news may be used (1) in the upgrading of teachers with inadequate science backgrounds, and (2) in giving students an understanding of the nature of science, of how scientists work, and a feeling of being vicariously "on the firing line" of the advance of science. For both groups it may serve to build a foundation for broad self-education in science.

Extensive studies of the science content of newspapers and magazines have been made, and some work has been done on methods of utilizing this material. A more or less complete bibliography of these studies is appended. Further study and experimentation in the utilization of science news at the elementary, secondary, college and graduate teacher-training levels is needed.

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## NEW U. S. OFFICE OF EDUCATION PUBLICATION

An atomic work force, 100,000 strong, already is employed in the United States in fields ranging from missiles to medicine, a new U. S. Office of Education publication indicates.

Termed "Careers in Atomic Energy," this booklet describes expanding uses of atomic energy, job opportunities, and training programs. The Atomic Energy Commission provided technical assistance in preparing the publication, in cooperation with staff members of the Department of Health, Education, and Welfare.

Types of work range from unskilled jobs to highly specialized scientific and technical positions. Chemists, geologists, miners, mathematicians, accountants, lawyers, typists, draftsmen, guards, electricians, storekeepers—these and dozens of other types of workers are required.

Increasing career opportunities, the publication explains, stem from applications of atomic science such as these:

1. *Manufacturing.* More than 1,000 industrial plants use radioisotopes in manufacturing processes. Radioisotope gauges, for example, measure and control the thickness of materials such as leather, paper, plastics, rubber, sheet metal, and textiles.

2. *Nuclear Power.* Four full-scale nuclear power plants are being built. Others are planned. By 1980 an estimated 67% of the new electric generating capacity added yearly in the U.S. will be nuclear. Merchant ships and military aircraft, as well as submarines, may be atomic powered.

3. *Agriculture.* Radioactive tracers show what happens to fertilizers during plant growth. More has been learned the past four years with radioisotopes than during the previous half century.

Plant genetics have been aided by isotopes, too. They have produced a peanut plant with 30% higher yield, resistance to leaf-spot diseases, and better adaptation to mechanical harvesting. Rust-resistant oats have been developed.

4. *Medicine.* Products of atomic energy aid in the study of anemia, arthritis, cancer, diabetes, heart disease, leukemia, mental diseases, nervous diseases, and some chronic illnesses. Tracers discover the paths and functions of certain matter, such as the blood. Thyroid cancer and brain tumors can be detected.

5. *Biology.* Radioactive materials reveal life processes and bring about genetic changes in animals as well as plants.

Universities, hospitals, and research institutions now have about 400 research contracts with the Atomic Energy Commission in the life sciences—biology, medicine, biophysics, and agriculture. In the physical sciences, universities have about 400 more contracts.

About 7,000 persons are employed directly by the Atomic Energy Commission. More than 90,000 others are hired by contractors with the AEC.

The rapidly growing radioisotope industry itself is providing considerable employment. In 1956, eight national Atomic Energy Commission laboratories employed about 16,500 persons. The Oak Ridge National Laboratory in Tennessee shipped 12,585 packages of radioisotopes to 2,360 institutions in every State and Territory and 46 foreign countries in 1955.

The publication was prepared by Walter J. Greenleaf, specialist in occupations, Office of Education, Department of Health, Education, and Welfare. Copies may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 25 cents a copy.

# NOTE ON WINTHROP'S "MATHEMATICS IN THE SOCIAL SCIENCES"

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In a recent issue of this journal, Winthrop [1] has performed a service for teachers of mathematics by bringing to their attention the report of the Social Science Research Council Committee on the Mathematical Training of Social Scientists [2]. He also presented some interesting examples of mathematical models in behavioral diffusion theory. The purpose of this note is to illustrate the ease with which these examples can be treated using the method of difference equations. Incidentally, this method will produce formulas incomparably simpler than those derived by Winthrop.

Our discussion will provide only a very small sample of the extensive use of difference equations in the social science literature. A much larger sample is available in a forthcoming textbook [3] which develops the mathematical theory of difference equations and contains many illustrative examples from economics, psychology, and sociology. Of course, in exploring this interdisciplinary domain of mathematical social science, readers will find not only difference equations, but many other mathematical ideas and techniques being used. Our bibliography lists four recent books [4, 5, 6, 7] which give a good indication of the nature of modern mathematical models in the social sciences.

The problem we shall treat is considered in [1] and may be stated as follows: the time scale is divided into intervals of equal length with endpoints arbitrarily labeled $t=0,1,2,\cdots$. At $t=0$ a person decides to start a rumor. During the ensuing period (from $t=0$ to $t=1$) he transmits the message to $\phi(1)$ other people. Each of the $\{1+\phi(1)\}$ people now knowing the rumor transmits it to $\phi(2)$ other people during the time interval from $t=1$ to $t=2$, and so on. In general, the function-value $\phi(t)$ denotes the number of persons to whom the message is passed (by each possessor of the message) during the interval from time $t-1$ to $t$. It is assumed that at each stage none of the rumor-receivers has already heard the message. The problem is to find an expression for $N(t)$, the total number of persons who have heard the rumor up to and including time $t$.

Each of the $N(t)$ individuals who have heard the rumor by time $t$ is either one of the $N(t-1)$ people who knew the rumor by time $t-1$, or one of the $\phi(t)N(t-1)$ people who heard the rumor during the time from $t-1$ to $t$. Since we have assumed no overlapping of these classes, it follows that

$$N(t)=N(t-1)+\phi(t)N(t-1) \qquad t=1,2,3,\cdots.$$

This *difference equation*, rewritten in the form

$$N(t)=\{1+\phi(t)\}N(t-1) \qquad t=1,2,3,\cdots, \tag{1}$$

together with the initial condition

$$N(0)=1, \tag{2}$$

which expresses the fact that a single individual starts the rumor at $t=0$, suffice to uniquely determine $N(t)$ for all positive integers $t$. For, putting $t=1$ in (1) and using (2), we obtain

$$N(1)=1+\phi(1). \tag{3}$$

Similarly, substituting $t=2$ in (1) and then noting (3),

$$N(2)=\{1+\phi(2)\}N(1)=\{1+\phi(2)\}\{1+\phi(1)\}.$$

Proceeding in this way, one finds

$$N(t)=\{1+\phi(t)\}\{1+\phi(t-1)\}\cdots\{1+\phi(1)\},$$

or using the familiar notation for products,

$$N(t)=\prod_{k=1}^{t}\{1+\phi(k)\} \qquad t=1,2,3,\cdots. \tag{4}$$

Formula (4) replaces the very unwieldy formula $(B')$ of [1]. As is so often the case once one has "derived" a formula of this kind, a formal *proof* that it is true for all positive integers $t$ can easily be given using mathematical induction.

In the special case $\phi(t)=m$, a constant, where every transmitter meets the same number of persons in all time intervals, (4) becomes

$$N(t)=\prod_{k=1}^{t}(1+m)=(1+m)^t,$$

which is formula $(A')$ of [1].

If $\phi(t)=t$, then

$$N(t)=\prod_{k=1}^{t}(1+k)=(t+1)!,$$

again much simpler than (but equivalent to) formula (28) in [1] which reads

$$N(t)=1+\sum_{k=1}^{t}k(k!).$$

For a proof of this equivalence we have only to note the identity

$$k(k!) = (k+1)! - k!.$$

Then

$$1 + \sum_{k=1}^{t} k(k!) = 1 + \sum_{k=1}^{t} [(k+1)! - k!]$$

$$= 1 + [(2! - 1!) + (3! - 2!) + \cdots + (t+1)! - t!].$$

The sum in brackets is an example of a "telescoping" sum, in which all but two terms cancel. We are left with

$$1 + \sum_{k=1}^{t} k(k!) = 1 + [(t+1)! - 1!]$$

$$= (t+1)!,$$

as claimed.

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## NEW KIND OF RADAR "SEES" LONG DISTANCES

A new kind of radar that can detect objects at greater distances with the same amount of power than present sets has been developed by scientists at Columbia University working under a U. S. Air Force contract.

The system provides a "lock and key" by which the radio pulse sent out to detect far-away objects, such as jet planes or guided missiles, is tagged so it can be identified when the signal returns from the target to the receiver. Present radar antennas can be adapted to use the method, but they would require new instruments.

The new radar system is expected to be used in the future wherever the detection of very weak signals is important. It works by trading time for power: fainter signals can be picked up by taking more time to gather the information they contain rather than by using more power.

The increase in effective power was reported to be "many hundreds of times" compared to that of World War II radars.

# CONSERVATION AND CAMPING

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The children of this generation will face many problems that never confronted those born in a more spacious era. The mounting birth rate in this country is producing many new demands. Some of these will be greatly increased food supply, larger demands for clothing and shelter, and an adequate education for all. The needs for school buildings and for teachers to staff an expanding educational program has been well publicized. However, what has not been emphasized sufficiently is that facet of education that is the one designed to prepare children to live effectively in an increasingly crowded land. This is that part of the curriculum known as "outdoor education." One of the most vital lessons learned in this phase of the educative process is that of conservation of the country's natural resources. Possibly, the best place to teach the wise use of resources is "outdoors" and the best learning situation for elementary children is a school camping experience. A report of a recently established program of school camping where parents, teachers, and children planned together may illustrate what has just been described.

## THE PROGRAM AT PERSHING SCHOOL

One of the schools which had a most successful camping expedition is Pershing School, of the Portage Township Schools, Portage Center, Michigan. The author was fortunate enough to participate in the pioneering of the project.

Two classes were chosen, a sixth and a combined fifth and sixth grades to try out the experiment. The Board of Education gave its qualified approval. The children and teachers were to assume nearly full responsibility for the success or failure of the venture. This included the assumption of the financial burden. Since the parents were important to this undertaking their full assent was desired.

A joint meeting of parents and school personnel was held shortly after the decision had been made to try a week's camping. The parents were apprised at this time of all the precautions that were to be taken for the health and safety of the children. The teacher who headed the staff was an expert swimmer who had experience both as a scoutmaster and lifeguard. He presented tentative plans that described the routine of a week at camp. Although the camp site was only ten miles from the school district, the parents were asked to avoid visiting or calling the children until the regular visiting night on Thursday. The value of some experience away from hovering parents was stressed. After the presentation, suggestions of the parents

were solicited and their questions answered.

The results of this planning session with parents were most satisfactory. The parents were unanimous in their approval and enthusiasm. They raised no question as to the competency of those teachers who were to supervise the sixty youngsters for the week away from home. Their whole-hearted cooperation was shown by the fact that they offered to underwrite the expenses that could not be met by the children.

In order to have a well balanced staff of both experienced and young counselors, help was sought from Western Michigan University. Through its assistance three young students were released from their regular studies in order to have the practical, first-hand experience of working with children. These young people were most carefully selected. The children liked and admired those advisors not much older than themselves.

The parents were informed that the Board of Education had offered to transport the children to and from camp. The visits of the school nurse were likewise provided. Perhaps the most praiseworthy gesture of the board was the loan of their best cook from the school cafeteria. All her menus were most carefully planned. Nothing was left to chance. Even the late evening snacks were considered and their expense calculated.

Since the major theme of the camp was to be conservation, extensive plans were made to include the various areas of fish and game conservation, wild life preservation, and the appreciation of natural beauty. Speakers from the state were secured as resource persons to demonstrate their own field of knowledge to the campers. Nature study was included as a part of the daily program.

With the parents well informed about the program for the campers nothing remained but to raise money for the venture to carry out the plans. Most of the money was earned by selling waste paper. This in itself was a valuable lesson in the art of wise use of materials. By salvaging this immense amount of paper which would otherwise have been discarded they were able to contribute over half of their expenses for the week at camp.

## The Camping Experience

Two school buses took the sixty children and their seven counselors to Pretty Lake Camp the second week in May. They were soon settled in a busy routine of swimming, boating, games, nature walks, arts and crafts and of course, eating. On three of the days talks were presented on some type of conservation. One was a specialist in fish and wild life. After the instructional period a walk was taken for the purpose of identifying any types of life seen on the trip. One large

snake was discovered which caused some consternation, particularly among the girls. When the conservation representative explained that few snakes were dangerous and that the one they saw was very beneficial to man because of the insects he ate, the plan to stone him was abandoned. On the same trip an observation was made of one of the junior counselor's fishing tactics. He was an able caster and he caught several fish while the children were watching. One was a bass and the rest were bluegills. It was pointed out to the group that since it was not the season for bass, the fish should, of course, be released. The bluegills were small and the conservation officer suggested that it would be better to let those fish go back to the lake to grow a little larger for another fisherman.

The counselor illustrated the right way to release a fish. Some fishermen jerked at the hook cruelly. A little time and patience spent in removing the hook gently did the fish no harm. The fish could be freed to swim once more gaily in the lake. Too many fishermen were greedy in taking more than their limit or they were careless in throwing small fish back. The conservation instructor told how plentiful the fish in the lakes of Michigan were at one time. Now, in spite of protective laws, many lakes and streams were depleted because of the thoughtless practices of some people. The right use of our natural resources left plenty for everyone.

On another day the leader was one skilled in the knowledge of woodlore. The surrounding area was searched carefully for the purpose of discovering and identifying as many varieties of trees as possible. Still another conservation guide was helpful in describing the relation of birds to the nice balance of nature. A few hardy souls rose early several mornings to "watch" birds with one of the counselors who was prepared to recognize most of the birds nesting in the vicinity.

The waterfront program placed a strong emphasis on the conservation of human resources. Life jackets were required gear for anyone who took out a canoe. Instruction in life saving was given to experienced swimmers. The "buddy" system was strictly enforced with several safety checks each swimming period. It was hoped by the staff that the safety precautions taken during the camping period would carry over into a characteristic form of response which would be a means of self preservation in later experiences.

On the last evening of the week the head counselor reviewed some of the most important events of the camp that had occurred. He spoke of those, who in a week's time, had become real "campers." By this term he explained he meant those who had learned to live graciously with others, doing their share of the tasks and perhaps even doing a little more than the required amount of work. The true

camper has respect for his surroundings. Hence he never leaves any camp site less beautiful than he found it. He is most careful to observe all safety rules about camp fires, realizing that one spark might start a raging forest fire that would kill countless wild animals and destroy trees that have been growing for a hundred years.

### Evaluation of Camping Experiences

The camping program of Pershing School was a marked success as was noted later in the letters of evaluation received from the parents of the campers. The children were wholeheartedly sold on the project. There were tears and sadness when they had to leave the camp which had become so dear to them because of shared experiences of work, play and learning.

From the participation that the author of this article had in this venture in outdoor living with children and teachers, she is convinced that camping is a valuable aid to learning in many areas. Of course, it cannot be stressed too much that the best results in camping come only when the program is well planned and organized. The daily camp routine must be almost too busy. Then there will be little chance of either boredom or homesickness.

Some of the most apparent benefits in this particular community were: (1) good parent and school relationships as a result of their mutual planning, (2) the development of the children's personalities due to the many varied experiences of selling products and earning money for the enterprise, (3) the increased ability to get along well with others in the close association of camp living, (4) the valuable lessons learned in conservation, swimming, and boating, and (5) last, the great amount of pure fun that every one had. In addition to all the immediate benefits there were many pleasures that could not be tabulated. One of these recurring pleasures was the sharing with children and parents the beautiful movies that were shown of the camp at various times throughout the next year.

Camping could be an important and useful part of school life. However, for the optimum results there should be very careful planning and thoughtful consideration of the many phases of a camping expedition by parents, teachers and pupils.

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### NEW ENZYME DRUG DISSOLVES DEATH-CAUSING BLOOD CLOTS

A new drug that may stop heart attacks by dissolving dangerous blood clots after they form in the body is now being tested in humans.

The drug is an enzyme known as plasmin and will be injected into the blood stream as soon as a blood clot is detected. If it works as well in humans as it has in animals, the clot will dissolve and the blood will return to normal within a few hours.

# A NOMOGRAPH BASED ON SOAP BUBBLE GEOMETRY[1]

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In Newman's excellent collection of articles and commentaries that make up his *World of Mathematics*,[2] there appears in volume 2 a section on the mathematics of Minima and Maxima. In teaching three plane geometry classes, this writer has found it possible to adapt the following work to an interesting and informative classroom activity.

C. V. Boys, in his article on soap bubble films and their properties,[3] gives the following proposition:

Let there be two soap bubbles, in general having different radii. If they come in contact, then (if neither bursts!) there are two possibilities:

a) *One* large bubble may be formed from the coalescing of the former *two* bubbles.

b) A *composite* bubble may be formed. (See Fig. 1.)

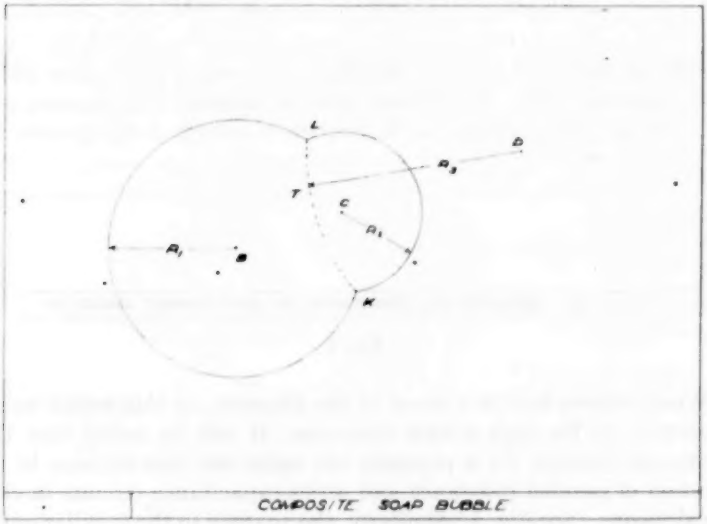


FIG. 1

In this latter case, the two "partial" bubbles are distinct; physical forces are in equilibrium; KTL is an *interface*, or film that separates

[1] The writer wishes to thank Fern Miller for criticism of the manuscript.

[2] Newman, James R., (Ed.), *The World of Mathematics*, vol. 2, Simon and Schuster, New York, 1956, pp. 726–1414.

[3] As found in Newman, *supra*, pp. 891–900; originally "The Soap Bubble," by C. Vernon Boys, taken from Boys' *Soap Bubbles: Their Colours and the Forces Which Mould Them*, New and Enlarged Edition, London, 1931.

the bubble on the left from the one on the right. Further, the final stable form of the two bubbles is such that "the total surface of the two spherical segments, and of the [interface], is the *smallest* possible surface which will contain the two quantities of air and keep them separate."[4] [Italics supplied.]

Fig. 2 shows the geometry that relates to the stable composite bubble situation. Boys states, but does not prove, that in Fig. 2, if[5] angle $BAC$ = angle $CAD = 60°$, then for arbitrary *collinear-points* $B,C,D$,

$$\frac{1}{AC} = \frac{1}{AB} + \frac{1}{AD}. \tag{1}$$

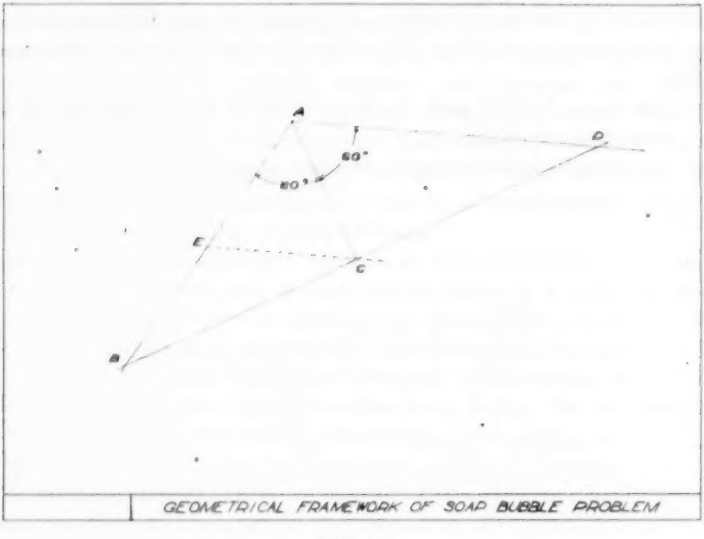


FIG. 2

What follows here is a proof of the theorem, as this writer would present it in his high school classroom. It will be noted that this reciprocal formula (1) is precisely the same one that appears in the solution of parallel-resistance and series-capacitance circuits in electrical theory. (See Fig. 3.) Similarly, the analogy to the familiar optics formula

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

is obvious.

[4] Newman, *op. cit.*, p. 897.

[5] A requirement necessary for physical equilibrium.

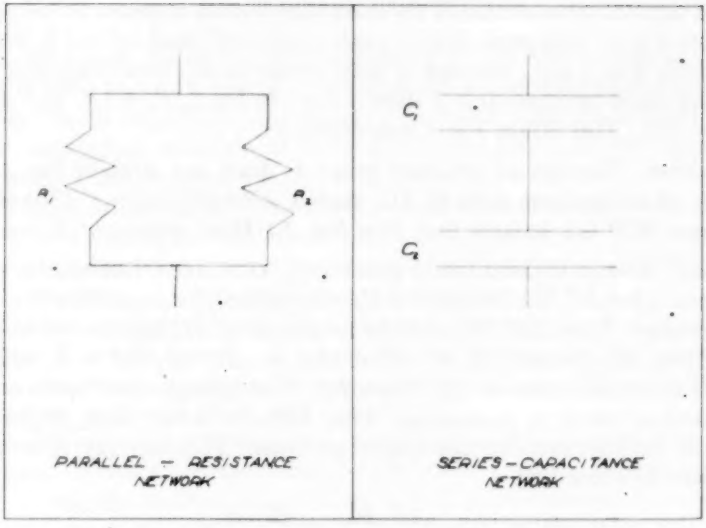


FIG. 3A FIG. 3B

The writer has worked out adaptations of the "bubble problem" to a nomographic solution of both electric and optic formulae, and the nomograph is drawn at the end of the article. (See Fig. 4.)

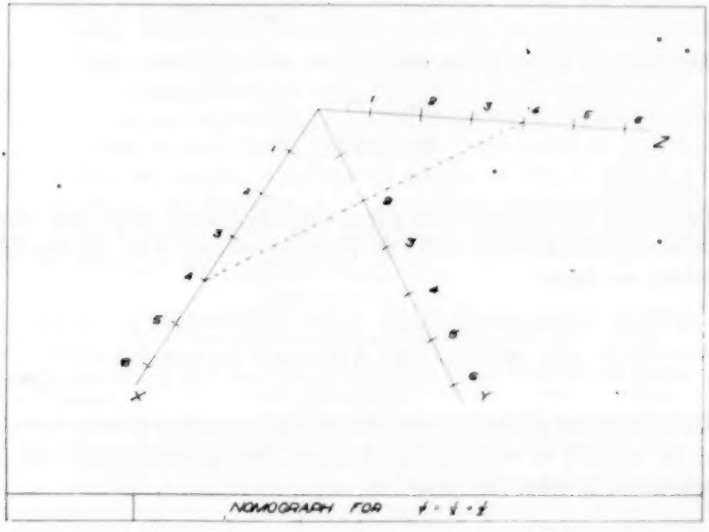


FIG. 4

A sagittal cross-section of the composite bubble is drawn as follows: From Fig. 2, with angle $BAC$ = angle $CAD = 60°$, and $AC < AB$, draw a circle $B \circ A$ (i.e., through $A$ with center at $B$). Now draw $C \circ A$. Draw arc of interface $D \circ A$ from $A$ to $C$. In Fig. 1, $R_1 = AB$, $R_2 = AC$, $R_3 = AD$. (This is how Fig. 1 was drawn.)

*Theorem:* Through an arbitrary point $A$, draw any straight line $AC$. Lay off on opposite sides of $AC$, angle $CAB = 60°$, angle $CAD = 60°$, where $BCD$ is a straight line. (See Fig. 2.) Then, equation (1) holds.

*Proof:* Assume without loss of generality, $AC < AB$. (Note that in the event $AB = AC$, the interface is a plane surface, i.e., a surface of zero curvature. Then $AD \| BC$, and the reciprocal of $AD$ approaches zero.)

Strike off distance $AC$ on $AB$, so that arc $AC$ cuts $AB$ at $E$, where $E$ is an interior point of $AB$. Draw $EC$. Now triangle $AEC$ is not only isosceles, but it is equilateral, with $AE = AC = EC$. Also, $EC \| AD$, since the alternate-interior angles are equal. To prove (1), it is sufficient to show that

$$AD = \frac{AB \cdot AC}{AB - AC} = \frac{AB \cdot AC}{BE}, \tag{2}$$

where by assumption $0 < BE$. Since the height of triangle $ABC$ and of triangle $ACD$ with respect to base $BD$ is the same, we have

$$AB \text{ Sin } (ABC) = AD \text{ Sin } (ADC), \text{ or}$$

$$AD = AB \times \frac{\text{Sin } (ABC)}{\text{Sin } (ADC)}. \tag{3}$$

Comparing (3) with (2), we note that if we can show

$$\frac{\text{Sin } (ABC)}{\text{Sin } (ADC)} = \frac{AC}{BE}$$

we are done.

But, from the construction previously described, note that angle $ADC$ = angle $BCE$, since $AD \| CE$. Then, in triangle $BEC$, by the Law of Sines, we have

$$\frac{\text{Sin } (CBE)}{\text{Sin } (BCE)} = \frac{CE}{BE} = \frac{AC}{AB - AE} = \frac{\text{Sin } (ABC)}{\text{Sin } (ADC)}$$

Q.E.D.

This foregoing analysis of the theoretical geometry of soap bubbles may be applied as follows: Fig. 4 shows how a nomograph may be constructed to solve the equation

$$\frac{1}{Y} = \frac{1}{X} + \frac{1}{Z}.$$

(Note that $X,Y,Z$, are the appropriate radii of the soap bubble circles.)

In the circuit of Fig. 3A, we may identify $Y$ with effective resistance and $X$ with $R_1$, and $Z$ with $R_2$. (Resistance here is usually expressed in ohms.) Or, in Fig. 3B, we may equate $Y$ to the effective capacitance in the circuit, and calculate it, given $X=C_1$ and $Z=C_2$. In the optics formula, $Y=f$, $X=p$, $Z=q$.

*In general*, given any two of $X$, $Y$, and $Z$ we may calculate the third quantity. The middle scale in Fig. 4 bisects the 120° angle formed by the two outer scales. Note that the three scales are linear and congruent, i.e., no compression of scales takes place.

*Sample problem:* Let $R_1=4$ ohms and $R_2=4$ ohms in Fig. 3A. Locate $R_1=4$ on $X$-scale, $R_2=4$ on $Z$-scale. Draw a line (or better, lay a *straight edge*) between these two points. On $Y$, read the effective resistance of the circuit to be 2 ohms.

Variables in the optics formula would be handled in an analogous manner. A little experimentation by the student with a straight edge will reveal the method of variation of the optics formula. On scale $Y$ here, one might want to align a second scale on the other side of $AC$ with readings of $R=2f$, where $R$ is the radius of a spherical mirror, often the object of consideration in geometrical optics. Note that given $R$ and $p$, for example, by *one* simple alignment we find *both* $f$ and $q$.

A physics class might well use a large alignment chart or nomograph with, say, units 1 cm. apart on all three identical linear scales. The outside dimensions of such a chart would be on the order of 2 feet by 3 feet. This would be accurate enough for most approximate work. Multipliers of 10, 100, or 1000, are easily accommodated into this scale for electronics work with resistance and capacitance.

Readers who are interested in the empirical verification of formula (1) are advised to read Boys' original article (as found in Newman). It is possible, by means of a drawing similar to Fig. 1, with a glass plate on top of the drawing, (the glass plate moistened with soap film), to blow hemispheres that match the contour of each bubble and the interface simultaneously.

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## BUREAU OF STANDARDS BETS SUNSPOT PEAK IN FUTURE

The National Bureau of Standards is betting against most of the world's experts in predicting that the peak in sunspot activity is still in the future and not last January.

It takes at least seven and a half months to find out when sunspots have been at their highest or lowest because of the internationally used mathematical formula by which maximum and minimum are computed.

Those who believe last January was the high point argue that in the period from August to December, 1956, the sun had a hefty number of spots. If the maximum is still to come, solar activity would have to continue to be extremely high.

# FISSION FOR ENERGY

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The history of civilization shows a close relationship between the utilization of energy and the progress of man. Years ago, man was restricted in his activities by the limits of his muscular energy and that of the animals he was able to harness. Then slightly over a century ago, heat engines were developed for transforming thermal energy into mechanical energy. Overnight great strides were made in the fields of transportation, industry, and construction. Still later the invention of electric motors and generators further advanced living standards.

The use of heat engines and electrical generators depends primarily on chemical fuels. For the past century the fossil fuels—coal, oil, and natural gas—have supplied the major portion of the world's energy requirements. It must be realized, however, that in the not too distant future these sources of energy will be largely exhausted.

At the present time the total power consumption each year for all countries is about $2\times10^{17}$ (200,000,000,000,000,000) British Thermal Units. Reliable estimates indicate that the energy content of all the coal that can be recovered, at no more than twice the present cost, amounts to $350\times10^{17}$ BTU, while that of oil and natural gas together is only $16\times10^{17}$ BTU.

Taking into account both the steadily growing population and the increasing per capita demand, it is probable that by the year 2000, the rate of energy utilization for the world will be close to $10\times10^{17}$ BTU per year. It does not take much arithmetic to realize then that in less than 100 years the economically useful reserves of fossil fuels will be virtually expended.

With this in mind, it is inevitable that new sources of power must be developed during the next fifty years or so if the earth is to support the growing population with some increase in living standards. Two possible sources are being actively explored by science: solar energy and nuclear energy. With the discovery of nuclear fission, the latter source seems a very definite and practical possibility, and it will be the one that will be discussed at length in this article.

Since the explosion of the atomic bomb back in the summer of 1945 words such as fission, fission products, chain reaction, and uranium-235 ($U^{235}$) have always "popped up" when scientists begin discussing nuclear energy. Let us try to explain briefly the meaning of these terms, and in so doing lay the basis for an understanding of nuclear energy.

Briefly recalling some elementary science to which many of us have

been exposed, we may state that matter is made of atoms, and these atoms are in turn composed of protons (positive particles of matter), electrons (negative particles of matter), and finally, neutrons (neutral particles of matter). Let us also recall that there are 92 natural elements, the lightest of which is hydrogen (element #1), the last and heaviest is uranium (element #92), and others such as copper, gold, silver, lead, and oxygen.

In 1939, a few months before the outbreak of World War II, Strassmann and Hahn, two German scientists, reported that they had split a uranium nucleus through the use of slow-moving neutrons. Since this first announcement scientists have found that if an atom of uranium is bombarded with a slow-moving neutron it is possible that the atom will temporarily accept this neutron, but in so doing it may become very unstable. In an extremely short time, this uranium atom with the extra neutron will explode into two and even possibly three lighter elements. This simply stated is the process of fission, the explosion of the heavy element uranium into lighter elements through the use of slow-moving neutrons; the lighter elements that are produced are referred to as "fission products."

Now most of these fission fragments have too many neutrons in their nuclei, and so there is a tendency for them to expel these extra neutrons almost immediately. In this way the process of fission not only gives rise to fission products, but also to one, two, or three new neutrons.

These new neutrons play an important role in the continuous production of nuclear energy. Since the process of fission in uranium was triggered by the addition of a single neutron to the uranium atom, the release of these new neutrons makes it probable that one or more nearby uranium atoms will capture these neutrons and will themselves now undergo fission. These atoms, during fission, will of course release additional neutrons, thus enabling what is called a chain reaction to be established.

This chain reaction in uranium can be made to occur either as a controlled chain reaction, from which useful power is obtained in regulated amounts, or as an explosive reaction. The explosive reaction is possible because of the fact that on the average, more than one neutron is released from each atom of uranium during the process of fission.

For simplicity, let us assume that an average of two neutrons is released during the fission of each uranium atom. These two neutrons can then cause the fission of two more uranium atoms. When these two atoms undergo fission, a total of four new neutrons will be released. These will cause four more uranium atoms to fission. This time there will be eight new neutrons released, and hence, eight more

fissions will occur from them, which in turn gives rise to sixteen more neutrons, and so on. It is apparent that after not too many generations of neutrons, the number of atoms undergoing fission rises into very large numbers. It is this type of increase in fissions, all of which occurs in less than one-millionth of a second, which enables the atomic bomb to be detonated.

Fortunately, it is possible to control the rate of the chain reaction. This can be achieved by seeing that all neutrons over and above one per fission are removed from the vicinity of fissionable uranium atoms. This can be accomplished by inserting into the mass of uranium another material which absorbs neutrons, but does not undergo fission. With the proper amount of absorber all neutrons except one per fission will be removed, allowing just enough to remain to maintain the chain reaction. In this way, the chain reaction is prohibited from increasing geometrically, and the result is a controlled chain reaction.

For each atom that undergoes fission a tremendous amount of energy is released. The source of this energy is matter itself. As far back as 1905, Albert Einstein, as one of the consequences of his special theory of relativity, pointed out that matter and energy are equivalent by the simple relation $E=mc^2$, where $E$ stands for energy, $m$ represents mass (or matter), and $c$ is the speed of light (a constant). During the fission process, a small amount of matter is converted into energy.

The major part, over 80%, of this energy appears as kinetic energy (*i.e.*, energy of motion) of the fission fragments and released neutrons. These fragments and neutrons fly away from the scene of the fission with extremely high velocities. As these fragments and neutrons are slowed down by collisions with other particles of matter, they impart some of their energy of motion to the surrounding matter, raising its temperature. (It has been estimated that the temperature near the center of an exploding atomic bomb is in the neighborhood of 2,000,000 degrees Fahrenheit.) Thus, the energy of fission manifests itself primarily as heat. In the case of a controlled chain reaction, it is then conceivable to withdraw this heat continuously and use it for the generation of steam; which steam can then be used to develop electrical or mechanical power.

In the previous discussion, we have used the term uranium rather loosely in referring to it as potentially fissionable. Not all natural uranium is fissionable. Uranium ore as it is found in nature is composed of two kinds: one type has only 143 neutrons in its nucleus, this is $U^{235}$; the other kind has 146 neutrons in its nucleus, this is $U^{238}$. It is only the $U^{235}$ that is found in the ore that is in itself fissionable. However, it has been found that $U^{238}$ can be converted into a synthetic new element called plutonium, and plutonium has been found to be

fissionable. So strictly speaking, practically all available uranium can be used itself, or converted into a fuel that is capable of producing nuclear energy. It might be well to point out that it has been estimated that uranium is 1000 times more plentiful than gold, 100 times as plentiful as silver, and almost as plentiful as lead.

A device which permits the assembly of a mass of fissionable material, such as $U^{235}$ or plutonium, and provides a means of controlling the chain reaction is called a nuclear reactor. Nuclear reactors also usually have a cooling system as a means for removing the heat that is developed.

In its simplest form, the nuclear reactor is not much more than a pile of uranium in a material (moderator) capable of slowing down neutrons to a speed at which they can be easily captured by the uranium atoms. For example, the very first nuclear reactor, constructed by Enrico Fermi under the football stands in Stagg Field at the University of Chicago back in 1942, was only a pile of graphite (carbon) bricks, some of which contained lumps of uranium, and all of it surrounded by thick concrete blocks to shield the operators from the radiations developed in the interior.

The basic parts of any nuclear reactor are: (1) fuel, (2) moderator, (3) coolant, (4) reflector, (5) control system, and (6) shield. Each of these plays an important role.

There are only three fissionable materials which can be used as fuels; two of these, $U^{235}$, found naturally, and plutonium, artificially prepared from non-fissionable $U^{238}$, were previously mentioned. A third fissionable fuel can be prepared, as was plutonium, by converting the element thorium (element #90). Reactor fuels are most often in solid form, shaped as rods, slugs, pellets, wire, flat plates, or other shapes which can be stacked in close proximity, but with enough space between them to allow a coolant to flow over each piece.

The slowing down of neutrons is accomplished through the use of materials known as moderators. As a neutron collides with atoms of the moderator, it loses a part of its kinetic energy to the atoms of the moderator. The atoms of the moderator must be very light, otherwise the very light neutrons might bounce off heavier atoms without imparting any of their energy to the heavy atoms; the situation is comparable to a fast moving ping-pong ball colliding with a heavy bowling ball or with another light ping-pong ball. Some of the more common moderators are water, heavy water, beryllium, and graphite (carbon).

Reactor coolants may be either gases or liquids. To be a good coolant, a fluid or gas must have good heat transfer properties, be stable at the temperatures in the reactor, and be relatively non-corrosive to the part of the reactor with which it comes in contact. The coolant

must not absorb neutrons to any appreciable extent, and should be free of impurities which absorb neutrons. The most commonly employed coolants are water, heavy water, liquid sodium, liquid sodium-potassium alloy, air, carbon dioxide, and helium.

In every nuclear reactor some neutrons escape from the region of the chain reaction. Since these neutrons are not available to assist in maintaining the chain reaction, an additional amount of fissionable fuel must be provided. To avoid this loss of neutrons, the reactor core is surrounded with a reflector whose function is to reverse the direction of many neutrons which normally would leak out. In general, good moderating materials are also good reflectors.

In a controlled chain reaction, neutron absorbers are placed in the region of the chain reaction to absorb enough of the neutrons produced in the process of fission to keep the reaction from running away with itself and exploding like an atomic bomb, and yet not enough to stop the reaction. The absorbers are usually present in the form of control rods, arranged so that they can be moved in and out of the reactor core. During operation, the control rods are adjusted to a position which allows the reactor to be run with a desired number of fissions per second, that is, at a desired power level. Control rods are usually made of an alloy of a high strength material, such as steel, with an element with a high probability for capturing neutrons, such as boron, cadmium, hafnium, or gadolinium.

During the operation of the reactor a large number of lethal atomic radiations issue in all directions from the core. These radiations consist of alpha and beta particles, gamma rays, neutrons, and fission fragments. For this reason, a shield consisting of five to eight feet of concrete must often surround a reactor completely to reduce the radiations to a safe value. In addition, neutron absorbing materials are frequently dispersed in the concrete.

One of the most remarkable facts about nuclear energy is the large amount that can be obtained from a small amount of fissionable material. The complete fission of one pound of uranium would liberate roughly $3.6\times10^{10}$ (36,000,000,000) BTU; this is equivalent to the energy produced in the combustion of 1300 tons of coal. Another comparison one might make is that the same amount of energy obtained from $\frac{1}{4}$ cubic inch of uranium is obtainable from 10,000,000 cubic feet of natural gas (the amount contained in those large storage tanks seen around some cities), from 8,000 cubic feet of coal (the amount of four railroad hoppers), or from 4,700 cubic feet of oil (the amount of two railway tank cars).

Along this same line, it might be pointed out that during the past winter the first atomic powered submarine, the *Nautilus*, returned to port to refuel for the first time. The *Nautilus* had been in operation for two years, traveling more than 50,000 miles during this time, and

the Navy says it had over 65% of its original uranium fuel still unused. The only purpose for the refueling this past winter was to insure the operation of the submarine at its top efficiency. During the two year period of operation the coolant around the reactor core acquired small amounts of impurities that absorb neutrons. It was mainly for this reason that the power plant of the *Nautilus* underwent its first refueling.

In view of the possible applications of nuclear power, it might appear that progress in the nuclear power field has been slow. This is not due to any shortage of ideas concerning reactor design. Because there are any number of variable factors among which a choice might be made, there are many acceptable solutions to the problem of designing a nuclear reactor. However, lack of experience makes it impossible to say which of these will be best for a given set of conditions.

For example, two reactors of distinctly different types have been constructed for use in submarines, namely, the Submarine Thermal Reactor (STR) and the Submarine Intermediate Reactor (SIR). The STR is a thermal reactor whose heat is removed by circulation of water under pressure. In the SIR, on the other hand, neutrons of intermediate energy cause most of the fissions, and the heat transfer medium is molten sodium. Each system is known to have both advantages and disadvantages, but until both reactors are operated for long periods of time it cannot be said which design will prove to be the better.

The general scientific principles upon which reactor design is based are now well established, but there are many problems of a technological nature that have not been completely resolved. In February, 1954, the Atomic Energy Commission decided to invest more than $200,000,000 in a program to develop economical nuclear power plants. This program, which has come to be known as the Five-Year Power Reactor Development Plan, includes five different reactor designs:

(1) Pressurized Water Reactor (PWR), under construction at Shippingport, Pennsylvania. When completed it will produce more than 60,000 kilowatts of electricity, which is sufficient to supply the present requirements of an average American city of nearly 100,000 population.
(2) Experimental Boiling Water Reactor (EBWR) which just began operation during the winter of 1956 at Argonne National Laboratory outside of Chicago. The power output of this station is 5,000 kilowatts of electricity.
(3) Homogeneous Reactor Test (HRT), now being constructed at Oak Ridge National Laboratory in Tennessee.
(4) Sodium-graphite Reactor Experiment (SRE), being built at Santa Susannah, California. The reactor has been completed, and the electrical generating portion of the plant is in the final stages of construction.
(5) Experimental Breeder Reactor (EBR-2), in the first stages of construction at Argonne National Laboratory. It is designed to produce 15,000 kilowatts of electricity.

The Five-Year Power Reactor Development Plan is by no means the extent of the efforts of the U. S. in the reactor field. There are almost twenty research reactors of widely different designs in the national laboratories; several huge uranium raw material and reprocessing plants are in operation; the Hanford and Savannah River reactors produce large quantities of plutonium for military weapons; the development of mobile propulsion units (for submarines, ships, and airplanes) is on a large scale basis; and many other efforts are under way.

It is hoped that this program will bring us within sight of the objectives of harnessing nuclear power on a cost basis that can compete with coal and oil. Conservative estimates place this date around 1980. But who knows what the ingenuity of man will develop in the next two decades?

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## FALLOUT MAY MEAN FARMERS WILL HAVE TO CHANGE CROPS

Farmers may have to change their practices and what they grow and the world's population may have to change its eating habits because of radioactive fallout.

The factor that can bring about these future changes is strontium-90, the radioactive element in fallout that seeks out calcium in food chains; is absorbed by plants, animals and man; is deposited and retained in bones; is transmitted to milk and the developing fetus; is known to cause bone tumors, and is suspected of causing leukemia.

Just how much stontium-90 gets into milk, for example, depends on the amount of calcium present all along the line in the chain from contaminated grass that a cow eats to the final processing of the milk in a dairy.

Although there is no immediate need for the world's farmers to make changes in their farming practices, it might become very necessary during a nuclear war.

Survival at such a time might then be aided by the cultivation of crops low in calcium relative to their caloric value. Potatoes, for example, appear to be a "particularly suitable crop." Leafy vegetables, on the other hand, are not.

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## BRAIN COOLING GIVES MORE TIME FOR HEART SURGERY

A new brain-cooling technique that allows heart surgeons almost twice as much time as they now have for surgery inside a stopped heart was reported by a Japanese surgeon, Dr. Kazumi Taguchi.

The brain cooling method allowed heart action to be successfully stopped for periods up to 14 minutes. Without it, the brain would have been damaged from lack of oxygen after only four minutes.

The brain is cooled by short circuiting its blood supply from the common carotid artery out of the body and into two plastic tubes. There, the blood is cooled down and then pumped back into the head. In this way, the brain's temperature is lowered to 65 degrees Fahrenheit while the rest of the body remains much warmer.

# THE DECIMAL POINT—YOUR SLAVE OR MASTER?

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The importance of properly locating the decimal point in the solution of problems cannot be overemphasized. No mathematician would dispute the fact that an error involving the location of a decimal point is one of the worst types of errors that can be made. In industry, for example, it is far better for an employee to state that he doesn't know how to complete the solution of a certain problem and to seek help or guidance than it is for him to seemingly solve the problem correctly although the answer be wrong because of a misplaced decimal point. Errors involving one or two units might prove to be very costly. Yet the lesser of two evils might be for an answer to be inaccurate by one or two units than it would be to miscalculate the position of the decimal point by one or two places and thus derive an answer ten or a hundred times as big as it should have been.

Because of its utilitarian value, the slide rule has become an instrument that found its way, almost without exception, into the technical division of all industries. Technically trained men as well as their assistants and production workers have an additional advantage if they can use the slide rule with ease. However, the ability to properly locate the decimal point is a major factor in determining the usefulness of the results. Other mechanical instruments enable their users to calculate rapidly the answers to mathematical problems that might otherwise require much tedious computation, but like the slide rule, fail completely to designate the position of the decimal point. Chief among the errors involving the use of calculating devices are those related to the decimal point.

Any degree of success with computing devices will obviously be governed largely by the method which helps position the decimal point. Several methods for its proper positioning are suggested in the various instruction manuals accompanying these devices. The methods vary all the way from simple inspection of the answer to determine its reasonableness to complicated methods which serve to invalidate the usefulness of the device.

All methods for properly locating the decimal point have advantages as well as limitations. Certainly the method of inspection has inherent merit because of its brevity, but unfortunately, has limited use because so many problems have answers that cannot be predetermined or even approximated without exerting undue effort. The plan herein presented is brief, yet functional, and can serve to enhance the value of computational devices by simplifying the task of locating the decimal point to the extent the process becomes a slave instead of a master.

### Rules for Multiplication

1. In each of the factors place a temporary decimal point (x) after the first significant digit.
2. Multiply the first significant digits (rounded off) and locate the temporary decimal point (x) in the product.
3. Note the number of places and direction of shift (− for left, + for right) necessary to move the temporary points to their real positions in all the factors and find their algebraic sum. This sum may be referred to as the correction number.
4. Move the temporary point in the product according to the direction and number of places indicated by the correction number.

### Illustrative Exercises

1. $2\ 45 \times 5\ 3.1 = 13\ 010^*$
   $\underset{+2}{\text{x}\longrightarrow}\quad \underset{+1}{\text{x}\longrightarrow}\quad \underset{+3}{\text{x}\longrightarrow}$

2. $.02\ 45 \times .005\ 31 = .00013\ 01$
   $\underset{-2}{\longleftarrow\text{x}}\quad \underset{-3}{\longleftarrow\text{x}}\quad \underset{-5}{\longleftarrow\text{x}}$

3. $2.45 \times 5\ 31 = 13\ 01.$
   $\text{x}\quad \underset{+2}{\text{x}\longrightarrow}\quad \underset{+2}{\text{x}\longrightarrow}$

4. $.2\ 45 \times 5\ 310 = 13\ 01$
   $\underset{-1}{\longleftarrow\text{x}}\quad \underset{+3}{\text{x}\longrightarrow}\quad \underset{+2}{\text{x}\longrightarrow}$

5. $6\ 500 \times 6\ 50 \times .6\ 5 = 274\ 6000$
   $\underset{+3}{\text{x}\longrightarrow}\quad \underset{+2}{\text{x}\longrightarrow}\quad \underset{-1}{\longleftarrow\text{x}}\quad \underset{+4}{\text{x}\longrightarrow}$

### Rules for Division

1. Place a temporary decimal point (x) after the first significant digit in the divisor and in the dividend.
2. Divide the first significant digit (rounded off) of the dividend by the first significant figure of the divisor and locate the temporary decimal point in the quotient.
3. Note the number of places and direction of shift necessary to move the temporary points in the dividend and divisor to their real location. The correction number in the quotient is their algebraic difference.
4. Move the temporary point in the quotient according to the direction and number of places indicated by the correction number.

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* Although the product is actually 13009.5, the slide rule cannot justify that degree of accuracy.

### Illustrative Exercises

1. $7\ 4250 \div 1\ 65 = 4\ 50$
   $\overset{x\longrightarrow}{+4}\quad \overset{x\rightarrow}{+2}\quad \overset{x\rightarrow}{+2}$

2. $7\ 4250 \div .001\ 65 = 4\ 5000000$
   $\overset{x\longrightarrow}{+4}\quad \overset{\longleftarrow x}{-3}\qquad x\longrightarrow +7$

3. $.07\ 425 \div .1\ 65 = .4\ 5$
   $\overset{\longleftarrow x}{-2}\quad \overset{\longleftarrow x}{-1}\quad \overset{\longleftarrow x}{-1}$

### Rules for Multiplication and Division

1. In each of the numerators and denominators place a temporary decimal point after the first significant digit.
2. Multiply the first significant digits (rounded off) of the numerators and divide by the product of the first significant figures of the denominators. Locate the temporary point in the answer.
3. Note the number of places and direction of shift necessary to move the temporary points in the numerators and find their algebraic sum; do likewise for the denominators. The correction number is the difference between the two sums.
4. Move the temporary point in the final answer according to the direction and number of places indicated by the correction number.

### Illustrative Exercise

$$\overset{\longleftarrow x}{-4}\ .0003 \times \frac{\overset{x\longrightarrow}{+3}\ 7\ 400}{\underset{x\longrightarrow}{+1}\ 2\ 9.8} \times \frac{\overset{\longleftarrow x}{-2}\ .02\ 73}{\underset{\longleftarrow x}{-2}\ .07\ 6} = \overset{\longleftarrow x}{-2}\ .02\ 676$$

The foregoing method for properly positioning the decimal point has been supported by such eminent authority as Prof. Carl Schuster, who was most instrumental in contributing to the growth of slide rule instruction. This plan can and should be taught in the secondary schools for the following reasons.

1. It can be taught (and learned) in a relatively short time.
2. It can aid the student to approximate or to estimate answers to problems involving multiplication and division.
3. It can be used to accurately, yet rapidly, locate the decimal point once the digits are obtained on computational devices such as calculating machines or slide rules.
4. It should help to re-enforce abilities already developed by establishing the relationship between the correction number and

the topics of standard numbers or index notation and the characteristic of logarithms.

5. It can facilitate the ability to use logarithms by showing that the number of places required to move a temporary decimal point placed after the first significant digit of a number to its actual location is the characteristic of the logarithm of the number.

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## FIND ASPIRIN AS GOOD AS CORTISONE FOR ARTHRITIS

That old medicine-cabinet standby, aspirin, is still as good as modern-day cortisone for treating arthritis, Drs. Frank D. Hart and E. G. L. Bywaters, London, reported to the Ninth International Congress on Rheumatic Diseases meeting.

The aspirin-cortisone study was carried on for three years at nine medical centers in Great Britain and included 100 rheumatoid arthritics half of whom were treated with aspirin while the other half received cortisone. The end results showed no striking difference between the two groups.

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## BRAIN INJECTION HELPS CEREBRAL PALSY VICTIMS

Cerebral palsy victims may be helped by a new brain operation which relieves their involuntary muscular movements. The surgical technique, called chemopallidectomy, involves an injection of chemicals deep into the brain and has been used in the past to help adult victims of Parkinson's disease.

Out of 30 children who have had the surgery, 20 of them were either cured of their involuntary movements or were noticeably helped.

The chemicals are injected into the region of the globus pallidus, in the lower middle part of the brain. They destroy tissue which is believed to cause the abnormal stimulation of the muscles.

But the value of the treatment lies in the fact that both senstation and the ability to move are not lost along with the involuntary movements.

Why the operation helps to relieve the tremor, rigidity and involuntary motion is not known and requires much more study.

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## STATIC ELECTRICITY USED IN NEW PAINT SPRAY PROCESS

A new process for painting steel parts better than by hand or ordinary paint-spray methods makes use of the same force that sometimes makes your hair "stand on end" when brushed on a dry day.

The principle used in the process is "electrostatic attraction," the electric force that makes oppositely charged particles attract, and similarly charged particles repel one another.

Republic Steel Corporation's Berger Division here is using this principle to paint steel school lockers. As the lockers go by on a conveyor, electric-eye-operated paint-spray guns start shooting through a hoop-shaped electrode charged with up to 100,000 volts. As the paint particles fly through the charged electrode, they pick up a negative charge and are irresistibly drawn to the steel lockers, which have been grounded to induce an opposite positive charge.

# FOUR LEVELS OF CONTROL ARE NEW CRITERIA FOR SCIENCE CURRICULUM CONSTRUCTION

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## I. THE NEED FOR NEW CURRICULUM CRITERIA

Science is an increasing activity of the people. As more and more science enters the stream of human life, better criteria are needed for the identification and selection of that which will be stressed in the instructional programs of the schools. We are all aware of the fact that there is now tremendous science material from which we must select. We are keenly aware of the fact that we cannot present all of what may even be considered basic. Yet most of us believe that it is important to attempt to sort out the best and that it does matter that the problems selected for student work relate to important categories of the environment. The criteria that have been adequate in the past no longer serve to guide in the selection of curriculum materials which are to be used for the purpose of developing an optimal program in science education.

In this article is suggested a technique which can be used for the solution to the problem of planning a comprehensive science curriculum. The procedure makes use of simple criteria which are defined, illustrated and applied in the following pages.

The criteria are not applicable to the specialized and technical fields of science. However, because of the responsibilities which general education has for opening the channels of experience and learning that lead into the specialized areas of study, the criteria should be of interest to science teachers and curriculum persons at all levels.

The criteria grew out of a search to achieve the following purposes for a general education science program.

First.—To achieve a balance between the experiences representing broad categories of science.

Second.—To achieve a grade to grade sequence and repeated experience with typical science phenomena.

Third.—To achieve a framework of study, in which science experiences would be representative investigations which call for and allow the development of specific abilities and skills.

Fourth.—To achieve the purposes stated First, Second and Third, and yet provide definitely for that very high degree of flexibility required to accommodate the varied characteristics of both our students and teachers at each grade level.

## II. Discovery of the Four Levels of Control as the New Criteria

The criterion which has proved most useful in our attempt to select science materials suited to the foregoing purposes originates in the deliberation of the following simple fact: The science which we learn and come to an understanding of provides us with a measurable degree or level of ability. This ability is expressed in our behavior as we attempt to adjust to or gain control over the environment which we have studied or experienced.

There are four identifiable degrees or levels of this ability to adjust to or gain control over the environment. Each of these four levels may be used as a criteria. Each level of control is a mental device which the curriculum planner or teacher may apply as he considers those aspects of the environment encompassed by the themes, topics or units which are proposed for study or which are found in the current instructional literature for use in the study of science.

The idea of four levels of control as a criteria for the selection of curriculum materials is new. These levels emerge from the fact that adjustment to or control over the environment is limited. It is limited by both the amount and kind of understanding which we now have about the environment and by the basic nature, structure or operation of the things that are identified for study. The fact to which the reader must be alerted is that all science understandings may be grouped and in fact are naturally grouped in terms of four levels of control which they provide to the learner.

## III. Definition of Four Levels of Control

At this point we will take our first look at the Four Levels of Control criteria:

Level I.—This is the level of intellectual and emotional adjustment or the level of no physical control. Here are grouped those concepts, ideas and things which when studied and understood, in terms of the best that is now known, are outside of man's ability to control. This limitation extends both to his own power to make physical adjustment which would enable him to adjust to the thing studied as well as control of the things or phenomena referred to.

This level allows and requires a mental and emotional adjustment to things that exist but over which man has no physical control at this time.

Level II.—This is the level of personal physical adjustment. This level of control includes those things which are cyclic or periodic in their nature and to which man may adjust his movements and planning. Here in his study he discovers the natural period or cycle which he cannot change. However, his understanding allows him to

make physical adjustment of his own body to avoid harm and to plan to profit from it when he understands the cycle.

This level II control is higher than that encompassed in level I.

Level III.—This is the level of remote control (through acts of others). The understandings and the phenomena included in this division of scientific study are valid items for group action and consideration. Here any amount of understanding which the individual may gain from study does not enable him to gain the ability to adjust to or bring under control the environmental phenomena represented. His understanding and will to act must be accompanied by a similar understanding and will to act by whole communities. Without the group understanding and will to act the individual is stranded and doomed by the forces which he comprehends but cannot individually control.

Level IV.—This is the level of direct and absolute personal control. The things and the understandings related to them provides the individual with the ability to manipulate the forces and the materials in his environment to achieve every purpose that his mind can conceive in relation to them.

## IV. Origin of New Categories of Study

Thus a specific degree or level of control is the one common element found in all of the materials that fall within a given category of science. The presence of that element in the materials being examined automatically classifies the curriculum material as belonging to that specific category.

In like manner all of the proposed curriculum materials may be cast against this four-level screen or grid and the end product resulting will consist of four broad categories of science. These four broad categories encompass the total environment or at least that part of the environment which is reflected in the curriculum materials now in use or proposed for use.

At this point we are able to make a fundamental generalization: All science concepts, ideas and phenomena may be grouped into categories which when experienced, learned about and understood permit man to gain those levels of control which have been defined as levels I, II, III, and IV above.

The following are the new categories of science which are to be used in the basic curriculum plan for the purposes of general education:

Category I.—Here level I control is the major criterion for science curriculum materials to be included.

Criteria: All of the curriculum materials in this category must relate to the concepts, ideas and phenomena whose content, nature,

structure or mode of operation permit man to gain that degree of control defined as control level I above. (Material appropriate for other categories are excluded.)

Category II.—Here level II control is the major criterion for science curriculum materials to be included.

Criteria: All of the curriculum materials in this category must relate to the concepts, ideas and phenomena whose content, nature, structure or mode of operation permit man to gain that degree of control defined as control level II above. (Material appropriate for other categories are excluded.)

Category III.—Here level III control is the major criterion for science curriculum materials to be included.

Criteria: All curriculum materials in this category must relate to the concepts, ideas, and phenomena whose content, nature, structure or mode of operation permit man to gain that degree of control defined as control level III above. (Materials appropriate for other categories are excluded.)

Category IV.—Here level IV control is the major criterion for curriculum materials to be included.

Criteria: All curriculum materials in this category must relate to the concepts, ideas and phenomena whose content, nature, structure or mode of operation permit man to gain that degree of control defined as control level IV above. (Materials appropriate for other categories are excluded.)

## V. Applications of the Criteria—Implementation or Use

### *Project A. For Curriculum Personnel, Teachers, Authors and Publishers*

The curriculum materials represented by your basic science textbooks, Uni-texts, supplementary materials and curriculum guides can be made more useful by categorizing all units, topics, themes or projects into the four major categories defined in Part IV above.

To start on that project the following form has been found to be a satisfactory guide.

### PART ONE

1. Definition of what to include in category I (This is the level of no physical control.)

There are many science themes, topics and units which when studied and understood provide only the ability to adjust the thinking and the feelings of the student. They provide him with no ability to adjust his physical body or to do anything which will bring the things studied under his control. The items in this area of study are important and the understandings are essential even though they relate only to the intelligence and the emotional fix of the student.

2. Typical themes that relate to this category I
   a. The star patterns in the night sky (Space is vast.)
   b. The rock layer record of life on the earth (The earth is old.)
   c. The story of the great glaciers (Great forces are at work.)
   d. The story of the ancient reptiles (Adjustment requires change.)

e. The solar system (There is order in the universe.)
f. The land forms and changes therein (Change is a constant.)

3. From the curriculum materials that you have at your disposal attempt to sort out some of the titles, themes or units which you believe belong in this category of science.

*Control Level One Themes Suggested by Kindergerten Teachers*

1. How does the sun help us?
2. How does the rain help us?
3. When do we have thunder and lightning?
4. Why does the sun give us day while no sun gives us night?
5. We live on the earth. What is its shape?
6. What else is there beside us? Water, sky, stars, clouds.
7. Are rocks new or old?
8. What kind of clouds are in the sky?

## PART TWO

1. Definition of what to include in category II (This is the level of personal adjustment and planning.)

There are a great variety of science units, topics, or broad themes which relate to the natural cycles, periods, rhythms or stages. The understanding of these phenomena provide an ability to adjust our own planning and movements. While we are unable to disrupt or modify the natural repetition we can, if we understand it, modify our own plans and actions in an intelligent way.

2. Typical themes that relate to this category II
   a. The seasons come and go.
   b. We keep time by the stars.
   c. The migrants have returned on schedule.
   d. The tide is out.
   e. Many forms of life show a metamorphic pattern.
   f. The metallic properties of the elements are well displayed by those in the low numbered families.
   g. Etc.

3. From the curriculum materials at your disposal attempt to sort out some of the titles, unit topics or themes which you believe can be identified with the content of this category of science.

*Control Level Two Themes Suggested by Junior Primary Teachers*

1. Animal behavior in the daytime and at night.
2. Why are the days different at different seasons?
3. How do the wild animals adjust to the seasons?
4. When and how do insects build their nests?
5. Effect of long days on living things.
6. Why is it colder at night in the winter time than in the summer time?
7. How does the season relate to our family?
8. How does the day and the night relate to our family?
9. What birds go south? Do some other animals migrate?
10. Do all animals adjust to winter in the same way that birds do?
11. What is the relation of the season to the birth and care of baby animals?
12. Recording the daily weather changes as observed. (What changes are recorded?)

## PART THREE

1. Definition of what to include in category III (This is the level of remote control.)

Through lack of understanding or through wanton and willful destruction man sometimes upsets the balance in nature and then awakens to the fact that he must, in order to survive or to maintain the standards to which he is accustomed, restore the balance by artificial means. This is but one of the areas in

the modern community in which the individual comes to realize and understand the action that is essential to the continued well-being of himself and others. It is also but one of the areas in which he comes to realize that his understanding and will to act must be accompanied by a similar awareness and willingness on the part of a great many other people. Without this group awareness and willingness the individual is powerless to save his own well-being or that of his associates.

2. Typical themes that relate to this category III
   a. Urban life brings many problems of sanitation.
   b. Communicable disease is still a major problem.
   c. Living standards are in part determined by the available supply of pure water.
   d. By improper practices more soil can be eroded from our land in one day than can be restored in hundreds of years.
   e. Atomic energy is a potential source to replace our dwindling reserve of other natural resources; it is also a potential for the destruction of all of the other natural resources including man himself.
   f. Many of the items offered for sale in the public market do not represent proper concern for the health and economic welfare of the consuming public.

3. From the curriculum materials which are now available to you attempt to select some of the unit topics, themes or major problems which you believe relate to the study and kind of understandings which are proper for inclusion in this category III.

*Control Level Three Themes Suggested by Second Grade Teachers*

1. Who are the health helpers in our community and why do we need them to help us keep well?
2. Who may not have all of the things such as paper, food, health that they want and need if we do not get everybody to know where these things come from? Where do the things we have and need come from?
3. How does keeping our city beautiful help to make us healthy, strong and secure?

PART FOUR

1. Definition of what to include in this category IV (This is the level of absolute personal control.)

The understandings to be gained in this category of study enable the individual to exercise individual, voluntary, active control within a wide range of the environment. Here he is able to gain control through understanding how to produce desired effects by the manipulation of materials and forces. In this area of his environment he may achieve the ability to transform matter into other forms or into energy itself. Likewise he is able to achieve a transformation of energy from one form into another which will better serve his needs at a particular time.

2. Typical themes that relate to this category IV
   a. Keeping ourselves and our pets healthy.
   b. Our use of machines.
   c. Sending messages over long distances.
   d. We travel on land, by water and through air and space.
   e. We keep ourselves and our homes warm or cool.
   f. We change darkness into light to meet our needs.
   g. We get plant and animal varieties to satisfy both our needs and our fancy.
   h. Etc.

3. From the curriculum materials at your disposal attempt to identify those unit topics or broad themes which you believe relate to this category of science IV.

*Control Level Four Themes Suggested by Third Grade Teachers*

1. What are some things that we can do with air?
2. What can we find out about a dry cell?

3. What things float in water in salt water in other liquids?
4. What things will dissolve in water?
5. What kind of foods have a lot of sugar in them?
6. Can we grow a mold garden?
7. Can we have tulip flowers for Easter from bulbs?
8. Can we keep aquarium animals alive in our classroom?
9. What happens when things get cold or hot?
10. What are some ways that we can use to send signals to other places?

*Project B. For Curriculum Personnel, Teachers, Authors and Publishers*

To assist you to evaluate your balance or lack of balance in your selection of units of work, it is helpful to identify the units that you have been presenting in relation to the four basic or major categories which should make up a balanced program. It is essential that this selection be definitely related to the work that you have planned to present during each semester. Our experience should now verify the basic fact that no one teacher, no one author, or no one curriculum planner can escape the responsibility to plan a balanced program of science experiences for each group of children during each semester of their life in the general education program. If we center our attention upon what is best for the children in a specific room for a specific semester, we cannot miss in our effort to meet our responsibility. When we plan to meet the general needs over even as much as two semesters we do not make proper allowance for the variable over which we have no control. The era of a broadcast, shotgun approaches to the science needs of children is drawing to a close.

List offerings in each category planned for each semester:

I. _____ _____

II. _____ _____

III. _____ _____

IV. _____ _____

*Project C. For Curriculum Personnel, Teachers, Authors and Publishers*

It quite often happens that the curriculum materials available for presentation in one or more of the major categories has not been well developed at certain grade levels or the materials that have been developed relate to too few themes on units. One of the essentials to the success of any program that is geared to the idea of flexibility needed to accommodate the characteristics of both students and teachers must also be geared to the idea that a wealth of resource material must be available relative to many, many topics or units. This has created and will continue to create an increasing demand for text-units at every grade level related to the themes which relate to each of the four major categories. Some of these will continue to be written by the teachers.

List suggested unit titles or themes to fill specific curriculum gaps at specific grades:

| | Category | Grade | Suggested Theme |
|---|---|---|---|
| I. | | | |
| II. | | | |
| III. | | | |
| IV. | | | |

## VI. Achievement of Our Purposes—An Evaluation and an Interpretation

A. We now have just four categories of science experience which can be balanced one against the other for a reasonable sequence. Each category contains equally significant materials for study. Thus we realize that our FIRST purpose can be achieved within a reasonable time span. We can achieve a balance between the experiences representing broad categories of science. Heretofore it has been impossible for us to retain an awareness of the many assorted categories, and many times the balance has been completely lost in the science experiences of our students. The result has been lopsided or overloaded experiences which we attempted to present. We have been forced to admit that the task was just getting beyond the limits of possible achievement. Four categories of significant experiences is a comfortable allotment for any teacher.

B. Our SECOND purpose prescribed that these categories of experience be woven into a pattern of repeated experiences with typical phenomena. To start with we have a wide selection of themes, topics or unit titles and much rich curriculum materials at our disposal. There is very little that we will have to write. It is largely a matter of sorting and categorizing what we have so that we can begin to make it fit the new curriculum plan. The sequence idea requires that each student shall have significant experiences in each of the four categories each semester. Experiences in each of the categories are typical and the sequence will be significant irrespective of the topic, theme or unit title that is selected for study. With that idea in mind let us move over to our FOURTH purpose for more guidance relative to sequence. We are looking at a new kind of sequence for the first time.

C. Our FOURTH purpose requires that we make definite provisions for a flexibility required to accommodate the characteristics of both our students and teachers at each grade level. *Semester by semester repetition of experience selected from each of the four categories cannot be compromised by the teacher, the student or by the curriculum expert.* However, this is not to be interpreted to mean semester by semester repetition of given specific topics or units. What is intended

is that each teacher is aware of the four categories represented by the semester's work, that she has a responsibility and privilege to wisely select from a wide list of categorized themes, topics or units which meet the unique characteristics of her own background and the characteristics of the children now in that class. New materials prepared for this work should take the form of uni-texts to close the gaps found to exist in any one of the four categories at any particular grade level. The emphasis is upon a multiplicity of carefully graded materials relative to each of the four elements in the curriculum plan.

D. Our THIRD purpose was to achieve a framework of study in which science experiences would be representative investigations which called for and allow the development of specific abilities.

The classification of all science into four major categories applies also in focusing our attention upon the needs of our students to develop their investigation techniques and abilities or skills. The four categories represent opportunities for four major types of investigation. Each type of investigation carries with it the related techniques, skills and abilities which are unique to that type of investigation. While it is true that each of the four categories may be and are being investigated constantly by the student and while each investigation bears a similarity to all others this does not exclude the most significant fact. Each category requires a type of investigation that is more individual and unique than it is a general kind of activity applicable to all categories of study. This is a most significant consideration.

## VII. Variations Expected and Accepted—Criticism Answered

The discussion up to this point has implied that a unit study once selected as representative of one of the categories would contain only those concepts or related materials and experiences which are relevant to that category or those which deal with but one of the four levels of adjustment to or control over the environment.

This implication is purposefully intended for use in planning and identification of the unit topics which will serve as the four major foci of study. In the actual instruction and learning it is expected that all levels of control will be considered with each topic or unit of study. In fact the unit framework might well be a repetition of the four levels of control. That aspect of the plan is to be recognized and encouraged. It will in no way lessen the validity or utility of the four levels of control concept.

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### FLINT PREPARES TO BECOME YOUNG SCIENCE HUB

Flint will host the Ninth National Science Fair next May, when about 300 high school scientists, together with their prize-winning scientific exhibits, will descend on this Michigan city to complete for national honors.

# SIMPLE ILLUSTRATIONS OF THE EINSTEIN MASS-ENERGY RELATIONSHIP

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Almost any schoolboy can tell us the fundamental idea behind the function of the atomic and hydrogen bombs. Energy is liberated as the result of conversion from matter, according to the relationship $E=mc^2$. Unfortunately, the use of these deadly weapons as an illustrative example of this important concept has become too common. Are there not illustrations more closely related to our courses in chemistry and physics which do not require the use of bombs as teaching aids?

Two ideas come to mind. First, the time honored separation of the laws of conservation of matter and of energy. Second, the concept of nuclear binding energy.

Many popular high school chemistry texts still insist upon separate statements of the laws of conservation of matter and of energy. It seems, however, an easy thing to present the matter-energy relationship properly in the first place.

We state that matter and energy are interchangeable according to the expression, $E=mc^2$, and that the sum of matter and energy is conserved.

To illustrate the conversion of matter to energy, we use a simple reaction encountered early in elementary chemistry, the combustion of carbon; $C+O_2 \rightarrow CO_2+E$ (heat). Traditionally, we would say that 12 grams of carbon unite with 32 grams of oxygen to form 44 grams of carbon dioxide. But a considerable quantity of heat energy is evolved, as any boy who has built a charcoal fire will attest. Has this heat been created? How do we explain the presence of this energy, which appears as if from nowhere?

The heat evolved in this reaction is 94,000 small calories per mole of carbon. One calorie is equal to $4.18\times10^7$ gm-cm$^2$/sec$^2$ (ergs). Hence the energy release in ergs is

$$\left(94{,}000\ \frac{\text{cal}}{\text{mole}}\right)\left(4.18\times10^{7}\ \frac{\text{ergs}}{\text{cal}}\right)=3.92\times10^{12}\frac{\text{ergs}}{\text{mole}}$$

Let us now find the mass equivalent to this amount of energy. Using the equation $E=mc^2$, where $E$ = energy in ergs, $m$ = mass in grams, and $c$ = speed of light $=3\times10^{10}$ cm/sec, we obtain the following result.

$$m=\frac{E}{c^2}=\frac{3.92\times10^{12}\ \text{gm}-\text{cm}^2/\text{sec}^2}{(3\times10^{10}\ \text{cm/sec})^2}=4.36\times10^{-9}\ \text{grams}$$

$$m=.00000000436\ \text{grams.}$$

We expect therefore, that instead of 44 grams of carbon dioxide, we should obtain 44 grams less $4.36\times10^{-9}$ grams. But no weighing device now known will give any indication of this very minute mass change. We should emphasize at this point that the loss in mass demonstrated above for exothermic reactions is the result of transference or sharing of electrons.

Perhaps an even more interesting illustration of the matter-energy relationship finds use when the concept of atomic structure is being studied. Conceding that probably only our best students will ask, "Why does the nucleus of the atom stay together?" we cannot, however, ignore the possibility of being faced with this question. In fact, we should anticipate it, and be ready with the answer.

This answer lies in the idea of a nuclear "binding energy," which is released when protons, neutrons, and electrons are assembled as atoms by nuclear attractive forces.

It is not difficult to determine the binding energy of atoms. Very careful experiments have enabled scientists to measure atomic masses with a high degree of precision. Similar measurements have given us precise values for the masses of the proton, neutron, and electron.

The determination of the binding energy consists of obtaining the sum of the masses of the atomic constituents, substracting the measured isotopic mass of the atom, and finding the energy equivalent of the difference, the "mass decrement."

As an example, let us use the carbon 12 atom, the structure of which is commonly discussed in elementary texts.

The masses of the free proton, neutron, and electron are as follows:

$$\text{mass of proton} = 1.007593 \text{ amu (atomic mass units)}$$

$$\text{mass of neutron} = 1.008982 \text{ amu}$$

$$\text{mass of electron} = 0.0005487 \text{ amu}.$$

The sum of the masses of these particles in the carbon 12 atom is

$$W = 6(1.007593 \text{ amu}) + 6(1.008982 \text{ amu}) + 6(0.0005487 \text{ amu})$$

$$W = 12.102742 \text{ amu}.$$

Now, the measured isotopic mass of carbon 12 is $M = 12.003844$ amu. The difference, $W - M$ is the mass decrement.

$$12.102742 \text{ amu} - 12.003844 \text{ amu} = 0.098898 \text{ amu}.$$

Since the value of one amu is $1.67\times10^{-24}$ grams, 0.098898 amu is

$$(0.098898 \text{ amu})(1.67\times10^{-24} \text{ gms/amu}) = 1.66159\times10^{-23} \text{ grams}.$$

We are now in a position to find the energy equivalent of this mass decrement.

$$E = mc^2$$
$$= (1.66159 \times 10^{-23} \text{ gms})(9 \times 10^{20} \text{ cm}^2/\text{sec}^2)$$
$$= 1.495431 \times 10^{-4} \text{ ergs}$$

(The student may find the following approximation of value in perceiving the magnitude of the erg as an energy unit; 1 ft−lb = 1.33 $\times 10^7$ ergs).

To summarize, nuclear forces in assembling the carbon 12 atom did work which released energy, accompanied by a decrease in mass. If the scientist desires to separate the nucleus, at least this amount of energy must be added.

The following is a table of the isotopic masses of those elements which are frequently used in elementary courses to illustrate atomic structure.

| *Element* | *Atomic No.* | *Isotope* | *Atomic Mass* |
|---|---|---|---|
| Hydrogen | 1 | $H^1$ | 1.008145 |
| Helium | 2 | $He^4$ | 4.003873 |
| Lithium | 3 | $Li^7$ | 7.01822 |
| Beryllium | 4 | $Be^9$ | 9.01504 |
| Boron | 5 | $B^{11}$ | 11.01280 |
| Carbon | 6 | $C^{12}$ | 12.003844 |
| Nitrogen | 7 | $N^{14}$ | 14.00755 |
| Oxygen | 8 | $O^{16}$ | 16.000000 |
| Magnesium | 12 | $Mg^{24}$ | 23.99300* |

Although this approach is a simple one, and does not treat nuclear forces in detail, it is believed that it is a sound introduction to what has been called "the new physics." Also, we lay the groundwork for a much deeper understanding of fission, fusion, and nuclear power applications.

* Data for this chart taken from *Nuclear Radiation Physics*, Lapp & Andrews, Prentice-Hall, 1954.

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## LEADED GASOLINES MAY THREATEN SOME WORKERS

Anti-knock gasoline additives containing lead may threaten the health of persons whose occupations keep them in heavy automobile traffic, although there is no health hazard to the majority of the population.

A study of tiny lead particles formed from the combustion of gasoline containing tetraethyl lead was reported by a University of Chicago chemist.

Persons who follow average occupations and spend only a normal amount of time in or near heavy traffic inhale only about one-third the maximum allowable concentration of lead particles.

With the small concentrations of lead particles in the atmosphere, no health hazard exists for most of the population, "except possibly to those whose occupations require a constant exposure to highway atmospheres."

She added, however, that "serious consideration ought to be given the matter in view of the expected increase in automobile population in the future."

# HOW WE IMPROVED OUR TEACHING OF THE STORY PROBLEMS IN ALGEBRA

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*Quincy High School, Quincy, Michigan*

The mathematics teacher has always been confronted with the problem of how to teach the verbal problem effectively.

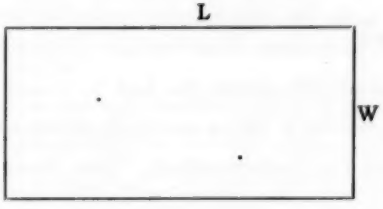
As a critic teacher in the Paw Paw training school it was my responsibility to attempt to improve the instruction of student teachers as well as the learning of ninth-grade algebra students, particularly in the area of the verbal problem. Investigations of the literature prove helpful in meeting the responsibility, especially the more noteworthy works by Nyberg, Lazer and Lygda.

A number of conferences were held with teachers of mathematics with respect to their activities with verbal problems. In general, they fell in two categories:

1. Those who eliminate the story problems from the year's work.
2. Those who follow the explanations found in the algebra text.

With this information we experimented for five years and finally developed a technique which we believe is more efficient than the traditional approach. The technique is essentially this. In the normal sequence of instruction the students are given their first assignment in verbal problems without much pre-explanation from the teacher. The next day the problems are discussed and visual diagrams are used to illustrate the solutions. For example, a rectangle is twice as long as it is wide. The perimeter is one hundred and fifty feet. Find the dimensions.

The problem is diagrammed on the board as follows:




$$P = 2w + 2L.$$

If $L = 2w$, then

$$P = 2w + 2(2w) \text{ or } 6w.$$

If $P$ also $= 150'$, then

$$6w = 150'.$$

A few students, the better ones, were able to understand the problems quite well. However, the majority were still in need of more help. This diagram technique was efficient when the problem was geometrically based. However, we are unable to picture non-geometrical problems effectively. Therefore, we decided as a class that we needed a more versatile plan. Instead of assigning more problems to work, the class spent part of the next few days reading and discussing story problems. Hence we developed this general structure.

A verbal problem contains three ideas. These ideas are sometimes contained in one sentence, sometimes in two, and often in three sentences. One of the ideas will identify the quantity we are to work with. Another idea will express the relationship between pairs or groups of the quantities. A third idea will generally state or imply a relationship involving all of the quantities. Identifying these ideas will enable one to write an equation. Thus, one discovers that in the solution of verbal problems an approach similar to this very useful. 1. Read the problem carefully to determine what is unknown and how many unknowns you are to find. 2. Read the problem again to determine the relationship that exists between pairs or groups of the quantities. This will enable one to represent them algebraically. 3. Read again to determine a relationship that exists between all the quantities. This will enable one to write an equation.

This outline was used as a guide in working the next assignment and was sufficient for a greater number of students. However, as many students still experienced difficulty, the next assignment necessitated that students write the problems verbatim, and underline with one line the words which tell how many quantities one was to find. Additional instructions were these: Underline the words which tell the relationship between pairs or groups with two lines. Underline the words which state the relationship stated or implied between all of quantities with three lines. For example: Separate 119 into 3 parts such that the second will exceed the first by 8 and the third will exceed twice the second by 3. What are the numbers? First, we discover that we are to find the three numbers. "Into three parts," what are the numbers?

Smallest Second Largest

Second, we discover the relationship between the numbers. Generally letting a letter represent the smallest and writing all other numbers in terms of the smallest, "Second will exceed the first by 8, and the third will exceed twice by second by three."

| Smallest | Second | Largest |
|---|---|---|
| $(x)$ | $x+8$ | $2(x+8)+3$ or $2x+19$ |

Third, we discover the relationship between all of the elements, "Separate 119."

| Smallest | | Second | | Largest | |
|---|---|---|---|---|---|
| $(x)$ | + | $x+8$ | + | $2x+19$ | $=119$ |

After following this structure for a few days the students are led to discover that this approach to a story problem will be of assistance to them in the solution of all verbal problems regardless of where they appear in the book. The following examples are taken from a standard algebra test.

*A*. One of two supplementary angles is one-nineteenth as large as the other. How large is each angle?

*Solution*

| 1. Small angle | Large angle |
|---|---|
| 2. $X$ | $19x$ |

3. $X+19X=180$

*B*. A purse contains 21 coins, consisting of nickels and dimes. Find the number of coins of each kind if their total value is \$1.65.

*Solution*

| 1. Nickels | Dimes |
|---|---|
| 2. $X$ | $21-X$ |

3. $5(X)+10(21-X)=1.65$

*C*. Sam is 12 years older than Henry, and Sam's age 10 years ago was $\frac{3}{4}$ of what Henry's age will be 6 years from now. Find the age of each.

*Solution*

| 1. Sam | Henry |
|---|---|
| 2. $X+12$ | $X$ |

3. $(X+12)-10=\frac{3}{4}(X+6)$

*D*. The denominator of a certain fraction exceeds the numerator by one. The reciprocal of the fraction exceeds the fraction by $\frac{7}{12}$. Find the original fraction.

*Solution*

| | | |
|---|---|---|
| 1. | Numerator | Denominator |
| 2. | $X$ | $X+1$ |
| 3. | $\frac{X+1}{X}-\frac{X}{X+1}=\frac{7}{12}$ | |

One recognizes that many problems, quoted are problems involving more than one unknown. It is also obvious that the students should not be lead to believe that mastery of the verbal problem is merely a blind adherence to a formal outline, as such a procedure certainly does not fulfill the total objectives of the course. As the students become more proficient, they are shown that many problems can be translated into symbols by writing the equation by using a letter for each unknown. *They soon realize that as long as they recognize the relationship that exists they may write the equation in many different ways.*

For example a student could have translated problem *A*. thus:

| | | |
|---|---|---|
| I | Smallest | Largest |
| II | $X$ | $Y$ |
| III | $Y=180-X$ and $Y=19X$ | |
| | then $180-X=19X$ | |

Or if we choose to write the relationship as this.

| | | |
|---|---|---|
| I | Smallest | Largest |
| II | $X$ | $Y$ |
| III | $Y=19X$ and $X+Y=180$ | |
| | then $X+19X=180$ | |

Thus we observe the concept of simultaneous equations and they can be discussed or referred to later. The better students are also encouraged to think of translating the problem in this way:

| | | |
|---|---|---|
| I | Small | Large |

II $\frac{X}{19}$ $\underline{X}$

III $\frac{X}{19}+X=180°$ or $180-X=\frac{X}{19}$ or

$180°=X+\frac{X}{19}$

Again as long as he recognizes the relationships, it makes little difference how he writes it down. It is obvious that there is no magic elixir to learning, and that students must be guided slowly and surely through learning experiences. Consequently one should not expect one hundred per cent efficiency from any of one's ideas, a weakness that we math teachers seem to have. But rather the teacher of mathematics should seek ways of improving the learning of children. He can do this by always keeping in mind the student and how he or she is reacting to the new situation and be willing to introduce new stimuli when needed. It seems more logical to direct the student to search for a thread of continuity that is in all story problems, and to furnish him with a general pattern which will enable him to become more efficient in his search, than it is to allow him to blindly search for the solution or to ignore the problems entirely.

In the pilot experiment nineteen out of twenty-nine students in the experimental class were able to successfully solve all the problems in a ten problem story test. In the control classes only six of twenty-four were able to solve them all correctly. While no statistical validity is claimed, it is believed that our experimental class benefited enough from this technique that it merited passing on to other math teachers for further investigations.

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## CANCER CURE IN DECADE GOAL OF FEDERAL RESEARCH

A cure for cancer within five to 10 years is one of the primary goals of the gigantic $240,000,000 attack on disease conducted by the Federal Government.

Through use of chemicals as yet undiscovered or unapplied, or the use of viruses, the attack on cancer may eventually be successful.

Other expected accomplishments, toward which research is being directed:

More infectious diseases will succumb to new antibiotics or chemicals, or be prevented by better vaccines.

The cause of mental diseases will be discovered and their cures will be accomplished.

Dietary and other methods of preventing diseases of the heart and blood vessels will be found.

The challenges posed by the increasing portion of our people who live into the upper age brackets will be met.

# SUGGESTIONS FOR THE STUDY OF NUCLEAR ENERGY IN THE SECONDARY SCHOOLS

THEODORE W. MUNCH
*The University of Texas, Austin, Texas*

Since the advent of the atomic bomb in 1945, much has been written concerning nuclear energy. Text books for high schools have tried to keep pace with the times by including a chapter on the basic nuclear reactions. In most books the treatment has been brief, and teachers may find themselves at a loss to choose from the welter of published materials salient points around which to organize the ideas of nuclear energy.

This paper suggests content for a unit for grades 8–12. Each teacher can adapt this material to the abilities of the students and the availability of materials. In light of the tremendous strides being made in this field, the subpoints under many of the main headings are not to be considered definitive. Teachers will constantly have to be alert to new materials as they are published.

## 1. SUBJECT MATTER BACKGROUND

1.1 Historical review. Contributions of Teller, Einstein, Oppenheimer, Fermi, Joliot, Soddy, Rutherford, the Curies, and Becquerel.

1.2 Nuclear theory

1.21 Ideas concerning the shape and size of the atom.

Matter → molecules → atoms → nucleus

Attempts should be made to make the nature of the nucleus as real as possible. For example: a drop of "nuclear" dew would be $130 \times 10^{12}$ times as heavy as ordinary dew

1.22 Ideas concerning nucleons and other sub-atomic particles

Basic particles: Protons, neutrons, electrons, mesons

It would be advantageous to write these particles symbolically: proton = ${}_1p^1$; neutron = ${}_0n^1$; electron = ${}_{-1}e^0$; alpha = ${}_2He^4$ or ${}_2\alpha^4$; beta = ${}_{-1}\beta^0$; gamma = $\gamma$

Mass units are written as superscripts; charge units as subscripts

1.23 Energy states in the nucleus

1.24 Isotopes

1.25 Nuclear binding energy

Packing loss

Binding energy

Amount of energy liberated in changing matter to energy is determined by $E = mc.^2$

1.3 Nuclear fission

1.31 Basic reactions in nuclear fission

Nucleus splits into two unequal parts

2–3 neutrons are lost from the nucleus

Part of nuclear mass is converted to energy, part of which is heat energy

Gamma rays, beta rays, alpha particles, and other particles are produced.

1.32 Nuclear *"bullets"*

To include alpha particles, protons, neutrons

Neutrons are most effective because they are not repulsed by protons

1.33 Fission chain reaction
1.331 Basic chain reaction
1.332 Controlled reaction. Nuclear reactors
1.3321 Basic components
Fuels
Materials—Uranium, Plutonium, Thorium
Size—Few pounds to tons
Shape—Slugs, bars, plates, liquid
Moderators
Control rods
Coolant
Heat exchanger in case power is to be delivered to an engine
Shielding
Basic types of reactors . . . classified according to
(1) use
(2) nature of assembly
(3) neutron energies
(4) fuel
(5) type of fuel-moderator assembly
(6) moderator Examples:
Submarine Intermediate Reactor
Experimental Breeder Reactor
Fast Breeder Reactor
Fluidized Solids Reactor
1.3322 Uncontrolled chain reactions
Atom bombs—fission principle
Thermonuclear bombs—fission-fusion-fission principle
Bomb Phenomenology—
Phenomena observable at site of detonation
Phenomena associated with the pressure wave from bomb
Phenomena associated with thermal effects from bomb
1.34 Energy release in nuclear fission
1.4 Social implications of nuclear energy
1.41 Generation of power
1.42 Use of atomic power to propel ships and aircraft
1.43 Production of rare earths and rare metals
1.44 Study of experimental work in radiation
1.45 Radioisotopes for use in medicine, industry, and agriculture as tracers and radiation emitters
1.46 Civilian defense against:
Radioactive fall-out
Atomic attack
Radiation hazards of atomic power plants
1.47 Disposal of radioactive wastes
1.48 Opportunities for employment in atomic industries

## 2. Demonstrations in Nuclear Energy

Certain basic pieces of equipment are necessary before much can be done in the way of demonstrations. This equipment, however, is not as prohibitive in cost as might first be imagined. None of the demonstrations need to be performed with research accuracy. Consequently, fairly simple equipment can be employed. The following basic components should be procured.

| *Item* | *Approximate Cost* | *Where to buy* |
|---|---|---|
| Count-rate meter | $190.00 | Tracerlab<br>130 High Street<br>Boston 10, Massachusetts |
| Radium button | $ 5.00 | Tracerlab |
| Radioisotopes | | |
| *Beta pack*—10 of P-32; 50 of S-35 | $ 5.00 | All of the packs listed are available from: |
| *Gamma pack*—10 of I-131, P-32; 50 of Cr.-51; 1 of Co-60 | $ 12.00 | Abbot Laboratories<br>Oak Ridge Division<br>Oak Ridge, Tennessee |
| *Jumbo pack*—nine isotopes of various kinds | $ 18.00 | All products are shipped air parcel post paid, or air express, prepaid |

The demonstrations suggested below may well follow the presentation of the content material outlines above, or may be interspersed during laboratory periods. It is suggested that the radioautographs be started early as they frequently take 4–20 days to develop properly. Some introductory material seems essential before starting the demonstrations. This is presented below. The instructor may wish to intersperse some of the demonstrations throughout the discussion of the subject matter background. The material under 2.1 should then be introduced when appropriate: I prefer to do all the demonstrations at one time.

2.1 Background material
- 2.11 Nuclear radiations
  - 2.111 Representative reactions which produce nuclear radiations
    - Alpha emissions
      - Eg. First step in the natural uranium disintegration series: $_{92}U^{238} \rightarrow {}_{90}Th^{234} + {}_{2}He^{4}$
    - Beta emissions
      - Eg. Decay of a common isotope: $_{15}P^{33} \rightarrow {}_{16}S^{32} + {}_{-1}B^{0}$
    - Gamma emissions
      - Eg. First step in the production of plutonium from uranium-238: $_{92}U^{238} + {}_{0}n^{1} \rightarrow {}_{92}U^{239} + \gamma$
    - Neutron emissions
      - Eg. The beryllium neutron source: $_{4}Be^{9} + {}_{2}He^{4} \rightarrow {}_{6}C^{12} + {}_{0}n^{1}$
  - 2.12 Representative observations which establish the characteristics of nuclear radiations
    - 2.121 Cloud chamber tracks
    - 2.122 Penetration studies
    - 2.123 Electrical charge deflection studies
    - 2.124 Bubble chamber tracks
  - 2.13 Characteristics of nuclear radiations which are used in the design of detection and measurement instruments
    - 2.131 Ionization effects
      - Geiger counter

Ionization chamber
Photographic film
Crystal conduction
Radiophotoluminescence

2.14 Measurement
- 2.141 Based on direct disintegration rate
  Half-life, Curie, microcurie, Rutherford
- 2.142 Based on ionization effect
  Roentgen, rep, rem, "n" units

2.15 Lethal Effects of Radiations

2.16 The count rate meter
- 2.161 Fundamental characteristics of the G-M tube
- 2.162 Operation of a typical instrument
- 2.163 Circuit of typical instrument
- 2.164 Minimum circuits for "do-it-yourself" Geiger counters

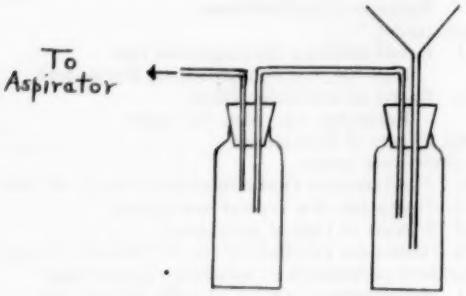
2.17 Laboratory procedures in handling radioisotopes*
- 2.171 Procurement. Order shortly before use is planned. Keep stored in shipping containers. Keep locked in a safe place. See bibliography for additional sources for procurement

*General considerations.* Sponge the work areas to remove dust. Operate in an area covered with several thicknesses of newspaper. Additional safety may be achieved by using a pan or glass plate on top of the newspaper. Keep the windows closed. Keep glassware used in demonstrations separate from other glassware. Always mark glassware distinctly. Never put hands into beakers used in demonstrations until the glassware has been scrubbed. A *surgical* scrub should be performed on any area of the body which has received direct contamination through spillage. A surgical scrub means 10 minutes scrubbing with soap, water, and a soft brush. Repeated rinsing is necessary. Wash hands thoroughly with soap and water or detergent after working with radioisotopes. This is especially important before smoking and eating. Wash all contaminated glassware with a good detergent

- 2.172 Use in the laboratory. *Clothing.* Wear a laboratory coat and clothing which may be easily discarded if contamination occurs. *Handling. DO NOT BOIL* radioactive solutions. Evaporate with a heat lamp placed over the sample which has been placed in a pan or beaker. Whenever possible, DO NOT POUR RADIOACTIVE SOLUTIONS. Decide on the amount of solution desired. If the radioisotope is in a water-soluble form, place a portion of the desired volume of DISTILLED water in the isotope container, swirl gently, and remove by pipetting. Repeat this process with the remaining portions of water. To transfer radioactive solutions, use a pipette. *DO NOT PIPETTE BY MOUTH.* Attach a 1–5 cc volume pipette to a piece of rubber tubing one inch in length. Attach a hypodermic syringe to the other end of the tubing. Holding the pipette-syringe apparatus in either one or both hands, draw the desired quantity into the pipette. Continue to draw the sample into the pipette so that no drops will fall from the end of the pipette. Carefully move the pipette to the desired location and discharge carefully. Rinse the pipette by using a wash bottle and the apparatus diagrammed on the following page. Then place the pipette in a beaker for later

* This section has been checked for accuracy by Dr. Leon Morgan, Associate Professor of Chemistry, The University of Texas.

decontamination. Store the first rinsing from the pipette in the active waste storage container




2.173 Disposal of waste radioisotopes. Keep solid and liquid wastes separate. Store wastes in wide mouth jars which are kept in stone crocks until radioactivity is negligible. Flush *spent* radioisotopes down the drain with copious amounts of water. Store long-lived and short-lived isotopes separately

2.2 Demonstrations

Those of a primarily physical science nature, using a radium button as a radioactive source

2.21 Calibration of a Geiger-Muller tube in connections with a count-rate meter

2.22 Effect of various shielding materials on radiation

2.23 Effect of distance on radiation

2.24 Absorption of radiation

Those of a primarily biological and chemical nature

2.25 Translocation of tagged atoms in plants, using young coleus or tomato plants

2.26 Radioautograph of radioactive leaf

2.27 Ingestion of radioisotopes in fish

2.28 Radioautograph of fish skeleton

2.29 Similarity in chemical behavior of nonradioactive and radioactive iodine

All of the above demonstrations may be found in *Laboratory Experiments with Radioisotopes in High School Science*. See the bibliography listed in this article for further details

## 3. Bibliography of Nuclear Energy Materials

The materials listed below represent a carefully selected list of items collected and used by the author who believes that they are of particular value to secondary school teachers. Many of the items are free. Many have been chosen because they make excellent display materials, and have clear photographs and drawings which can be projected with an opaque projector by duplication on 4×5 slides through photographic processes.

3.1 Basic facts about nuclear energy

*Sourcebook on Atomic Energy*. Samuel Glasstone. Van Nostrand, New York, N. Y. 1950. Approximate cost $5.00.

*Explaining the Atom*. Selig Hecht. Viking Press. New York, 1947. 205 pp. $3.00.

*Atomic Energy—How?* Consolidated Edison Company of New York. 4 Irving Place, New York 3, N. Y. 11 pp. Free.

*You Can Understand the Atom.* U. S. Atomic Energy Commission. Available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 22 pp. Cost unknown.

3.2 Bibliographies of Selected Readings on Atomic Energy

*Selected Readings on Atomic Energy.* U. S. Government Printing Office, Superintendent of Documents, Washington 25, D. C.

*Free and Inexpensive Literature Relating to Atomic Energy.* Available from the Educational Section, American Museum of Atomic Energy, P. O. Box 117, Oak Ridge, Tennessee. Free.

*Atomic Energy Commission Research Reports.* Price list #27, January, 1957. Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., 57 pp. Cost unknown, approximately 25¢.

*What's Available in the Unclassified Atomic Energy Literature?* January, 1957. TID-4550 (3rd Division) U.S.A.E.C. Technical Information Service Extension, Oak Ridge Tennessee, 36 pp. Approximately 25¢.

*Selected Publications Concerning Uranium Minerals and Prospecting.* July, 1956. U.S.A.E.C. Division of Raw Materials, Washington 25, D. C. 8 pp. 5¢.

3.3 Film Bibliographies on Nuclear Energy

*Films.* Available from the U. S. Atomic Energy Commission, Public Information Service, 1901 Constitution Avenue, Washington 25, D. C. Free.

*Film Helps.* Prepared by the U. S. Atomic Energy Commission. Request from the Educational Section, American Museum of Atomic Energy, Box 117, Oak Ridge, Tennessee. Free.

3.4 Uranium Mining Operations

*Mesa Miracle.* Prepared by the U. S. Vanadium Company, Division of Union Carbide and Carbon Corp., Grand Junction, Colorado. Order from the address above. Free.

*The Petrified River—The Story of Uranium.* Public Relations Department, Union Carbide and Carbon Corp. 30 East 42nd Street, New York 17, N. Y. 25 pp. Free.

3.5 Atomic Tools

*Atomic Tools for the Chemist.* Reprint from the *Dow* January, 1956. Available from the Dow Chemical Co., Midland, Michigan. Free.

*Light Metallurgy, The Building of a Nuclear Reactor.* Reprint from *Metal Progress*, July, 1953. Free.

*Electric Power Plant Reactors*, SGR and OMR. Available from Atomics International, P. O. Box 309, Canoga Park, California. Free.

*Nuclear Reactor Catalog and Supplement to the Nuclear Reactor Catalog.* H. S. Isbin, University of Minnesota. Reprinted from *Nucleonics*, March, 1952, Vol. 10, #3, pp. 10–16 and from June, 1953, Vol. 11, #6, pp. 65–59, respectively. Available from McGraw-Hill Publishing Co., 330 West 42nd Street, New York 26, N. Y. Cost unknown.

*Nuclear Test Reactor, Light Water and Oil Moderated Reactor.* Available from Atomic Power Equipment Department, General Electric Company, Schenectady 5, New York. Free.

*Radiatector and Radiameter.* Two single sheet brochures. Available from Curtiss Wright Corporation, Electronics Division, Carlstadt, New Jersey. Free.

*The Atom in our Hands.* Available from Union Carbide and Carbon Corporation, 30 East 42nd St., New York 17, N. Y. Free.

*Atomic Power for Peace.* Special Issue of *General Electric Review*, November, 1955. Write to General Electric Review, In Care of the Editor, Schenectady 5, New York.

*Atomic Tools for the Chemist*, Reprint from *Dow Diamond*, Jan., 1956. Dow Chemical Company, Midland, Michigan. 6 pp. Free.

3.6 Experiments and demonstration with radioisotopes

*Laboratory Experiments with Radioisotopes in High School Science*, 1953. Available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. 53 pp. 30¢. Now out of print.

*Radioactive Tracer Techniques*. Schweitzer and Whitney. 1949. Van Nostrand Co., N. Y. 241 pp. Approximately $4.00

3.7 Miscellaneous

*The Radioactive Fallout Problem*. Civil Defense Technical Bulletin, T.B.-19-1. Available from the Superintendent of Documents, Washington 25, D. C. 31 pp. 10¢.

*What You Should Know about Radioactive Fallout*. Civil Defense Bulletin #PA-7. Available from the Superintendent of Documents, Washington 25, D. C. 31 pp. 10¢.

*Radioisotopes—Uses—Hazards—Controls*. 1954. Available from Isotopes Division, U. S. Atomic Energy Commission, Oak Ridge, Tennessee. 15 pp. Free.

*Safe Handling of Radioactive Isotopes*. National Bureau of Standards, Handbook #42, 1949. Available from the Superintendent of Documents, Washington 25 D. C., 30 pp. 15¢.

*A Simplified Geiger-Mueller Counter Circuit*, H. D. LeVine, Jan., 1950. Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. 11 pp. 15¢.

*Peaceful Uses of Atomic Energy*. Dept. of State Publication #5888, June, 1955. Available from Supt. of Documents, Government Printing Office, Washington 25, D. C. 13 pp. 15¢.

*Two and Two-Thirds Seconds*. Large chart showing stop motion pictures of 15 kiloton atomic explosion. Superintendent of Documents. Approximately 10¢. $6.75/100.

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# PARALLEL-SERIES COMBINATIONS

## (NUMBER THREE IN A SERIES)

HARALD C. JENSEN

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There are several commercially available lamp board rheostats which may be used for illustrating parallel-series combinations of lamps.[1] All of these, however, use single-pole single-throw switches and the number of combinations is limited. Another circuit,[2] not available commercially and not so well known, employs single-pole double-throw switches.[3] When these are connected in the manner shown in Figures 1 and 2 the switching is more flexible and the number of possible combinations is much greater.

The lamps used in this apparatus may, of course, be any size. If the circuit is to be operated from the AC line, 120 volt—25 watt lamps are convenient. In case it is deemed advisable to use a step

[1] Welch #2800, Cambasco #65-538, or Cenco #83030.

[2] C. R. Fountain, *The American Physics Teacher*, 4, p. 132, 1936.

[3] Obtained from any supplier of radio or electronic parts.

down transformer as a source, flashlight bulbs would be appropriate. For example, a 6.3 volt 5 ampere filament transformer[3] could be used as a source for bulbs intended for a four cell flashlight. The number of lamps need not be limited to four.

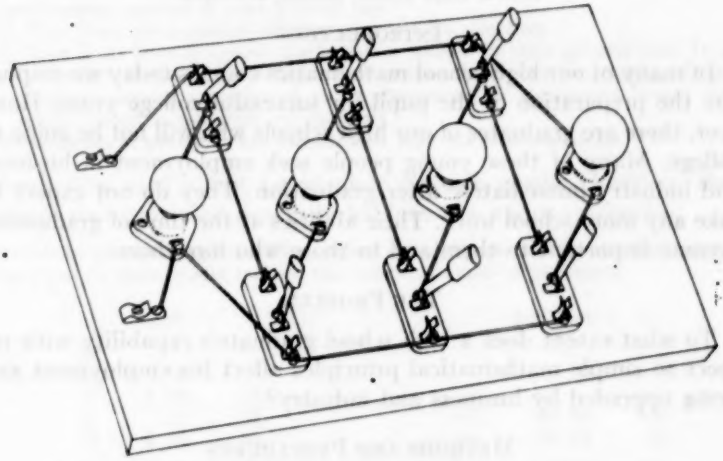

FIG. 1. A sketch of an apparatus used to illustrate parallel-series combinations.

Since it is impossible to make a short circuit by any combination of the switches, this apparatus is suitable for exhibit or museum purposes in addition to use as a demonstration piece. The circuit also has quantitative possibilities if an ammeter is inserted in series with the source.

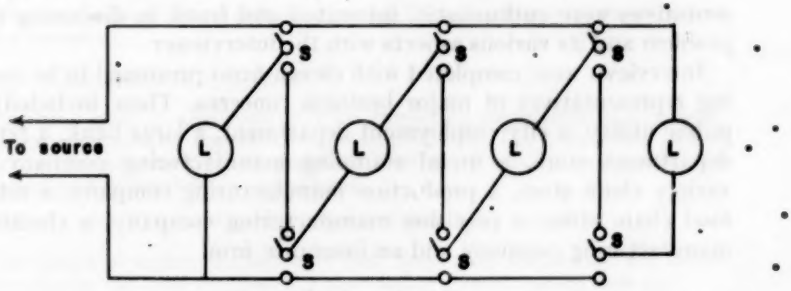


FIG. 2. Schematic diagram of lamps $L$ and single-pole double-throw switches $S$ in a circuit used to illustrate parallel-series combinations.

[3]Obtained from any supplier of radio or electronic parts.

# MATHEMATICS CAPABILITY AND EMPLOYMENT OPPORTUNITIES

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## INTRODUCTION

In many of our high school mathematics courses today we emphasize the preparation of the pupil for successful college years. However, there are graduates of our high schools who will not be going to college. Many of these young people seek employment in business and industry immediately after graduation. They do not expect to take any more school work. Their abilities at the time of graduation become important to them and to those who hire them.

## THE PROBLEM

To what extent does a high school graduate's capability with respect to simple mathematical principles affect his employment and being upgraded by business and industry?

## METHODS AND PROCEDURES

The study reported here attempts to learn directly from employers the answers to our problem. A questionnaire was drawn up requesting information. It dealt mainly with the content of and the minimum achievement standards on tests that employers use for initial employment, selection and for upgrading employees.

The problem and the questionnaire were discussed in a personal interview with an executive member of the personnel department of each of the cooperating firms. In every interview the executive representatives were enthusiastic, interested and frank in discussing the problem and its various aspects with the interviewer.

Interviews were completed with eleven firms presumed to be leading representatives of major business concerns. These included: a public utility, a city employment department, a large bank, a retail department store, a metal stamping manufacturing company, a variety chain store, a production manufacturing company, a retail food chain store, a precision manufacturing company, a chemical manufacturing company and an insurance firm.

## INTERVIEW DATA

When the interviews were completed the results were tabulated as well as other pertinent data gathered during the interviews. The questions used and the summarized results are given here. Where the tabulations are incomplete it indicates that certain firms did not

have specific data applicable to that question.

1. Are tests used as tools for selection?
   a. Ten of the firms use tests for selection.
   b. One firm refers to the applicant's high school record without giving a test of its own.
2. Do you use a special mathematics test for selection? Or is there a special mathematics section in your general test?
   a. Five firms use a special mathematics test for selection.
   b. Five firms have a special mathematics section in their general test. In a majority of the general tests each section is scored separately. These separate scores are referred to to determine an applicant's fitness for employment in a specific job category.
3. What types of problems are included on your mathematics test?

Each firm used a test based upon its own needs. However, the types of problems used generally fell into two major categories:

a. Problems given to applicants for clerical or sales personnel. A test that might be given to them would include the following types of problems:

Add

| | | |
|---|---|---|
| 56 | | |
| 48 | .18 | |
| 79 | 1.98 | $2\frac{1}{4}$ |
| 51 | .65 | $15\frac{1}{2}$ |
| 27 | 4.04 | $8\frac{3}{4}$ |

Subtract

| | | |
|---|---|---|
| 928 | 584.68 | $14\frac{3}{4}$ |
| 542 | 90.78 | $2\frac{1}{4}$ |

Divide

$8\overline{)6251}$ $\quad \frac{3}{4} \div 1\frac{1}{2} =$

Multiply

| | | |
|---|---|---|
| 467 | 22.16 | $\frac{1}{4} \times 1\frac{1}{2} =$ |
| 28 | $2\frac{1}{4}$ | |

28% of 254 = $\quad$ $(4)^3 =$ $\quad$ \$24 less 20% =

An article sells for 55¢ a pound. How much will $\frac{3}{4}$ of a pound cost?

What is the total cost of four articles at \$.18 each and one dozen articles at \$.35 a dozen?

How many ounces in $2\frac{1}{4}$ pounds?

b. Problems given to applicants in firms employing manufacturing personnel, or to applicants for apprentice training programs. The tests given to this group included the types of problems listed for the above group with the following additional types of problems:

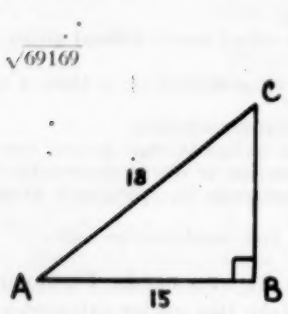
Milk sells for \$.24 a quart. How much will four gallons cost?

The length of a piece of steel is 16 feet. How many pieces each $10\frac{1}{2}$ inches long can be cut from the piece if $\frac{1}{8}$ of an inch is wasted making each cut?

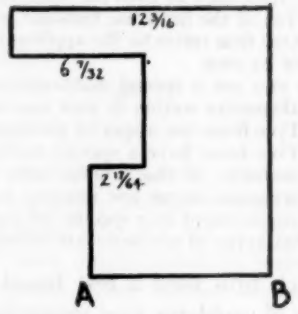
An employee received \$60 for a 45 hour week. For time over 45 hours he was paid at the rate of $1\frac{1}{2}$ times his regular hourly rate. How much will he receive if he works 50 hours one week?

An article marked \$14.00 is to sell at 25% discount. For how much will it sell?

A man has \$6000 invested at 4% and \$2000 at 5%. How much must he invest at 8% to make an average of 6% on his total investment?




Find the length of line *BC*.




Find the length of line *AB*.

Most of the tests were timed. On tests where there was no set time limit the amount of time taken to complete the test was used as a partial basis in the final rating of the applicant.

The interviewer had an opportunity at several of the firms to examine tests previously given to applicants. It was interesting to note that in the majority of these tests examined, where there was a choice of various questions the mathematics questions were the ones omitted by the applicant.

4. Does the degree of competency in mathematics alone influence initial employment?
   a. Four firms indicated the mathematics score alone to be the determining factor in employment.
   b. Three firms indicated a low score on the mathematics section influenced selection.
   c. One firm with over 200 job classifications indicated that in 85% of the jobs the mathematics score influences selection.
   d. One firm uses the mathematics scores on the applicant's high school records as a strong basis for selection.
5. What degree of accuracy is required or what is the minimum acceptable achievement in mathematics on a test?
   a. One firm uses 85% as the minimum for a sales job.
   b. Two firms use 67% as the minimum for limited positions.
   c. One firm uses 84% for clerical positions.
   d. One firm indicated that its median score was 12.8 on a 36 problem test.
6. Is mathematics a factor in upgrading or apprentice training?
   a. In eight of the firms contacted one's ability in mathematics is a strong factor in upgrading.
   b. All of the firms that have apprentice training programs stressed the importance of mathematical skills. They expect applicants for these programs to have completed high school algebra and geometry.
7. How successful are applicants in passing the selective tests where mathematics is a factor?
   a. One firm indicated 70% failed to qualify.
   b. One firm indicated 75% failed to qualify.
   c. One firm indicated that from 50 to 75% failed to qualify, depending on the job classification.

d. One firm indicated 33% failed to qualify.
e. Five of the firms stated that if an applicant failed to qualify on the mathematics tests he might be placed in a job classification where mathematics would not be a prerequisite.


## Summary

In so far as the methods used in this study may be valid, and presuming the firms interviewed to be truly representative in the employment practices in their respective fields, the following summaries may be made:

1. The general practice in business and industry today is to use tests as a basis for selection of employees. (data 1)
2. Mathematics questions are an extremely important part of the tests given. (data 2)
3. The mathematics problems found on these tests are confined mainly to the four fundamental processes of arithmetic with a few verbal problems. Harder problems are found on the tests used for those entering apprentice training programs. (data 3)
4. An applicant's capability in mathematics alone may determine his fitness for employment. (data 4)
5. The degree of achievement expected on the mathematics tests varied from 33% to 85%. (data 5)
6. Mathematics is important if an employee expects to be upgraded or expects to enter an apprentice training program. (data 6)
7. A large percentage of the applicants who apply fail to qualify because they lack the necessary mathematical skills. (data 7)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# A DEMONSTRATION STROBOSCOPE


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Will the cost of new equipment be educationally amortized by increased learning efficiency? This is the basic question which any science teacher must answer before asking for costly apparatus. The use of the stroboscope is limited to physics classes where discussions may become quantitative, and shop classes where the device is applied. The shop can use a commercial product which operates on the timing system of a car. For those physics teachers who have not the time needed to construct an electrically driven timer, the following demonstration needs no preparation.

Obtain a motion picture projector from the audiovisual department of your school. If bizarre uses of the equipment frustrate the bookkeeping, procure a film showing accelerating wagon wheels for illustration. If possible, get one of the old variable speed silent projectors. It will not give as much speed as the modern sound version, but a

continuous variation over the two speeds is a valuable quality. The disadvantage of the tinted heat guard falling at very low speeds is nil, since these speeds are below the flicker point. For higher frequencies ionized gas tubes may be used with alternating currents.

As for moving objects, wheels may be constructed and manually rotated. However, a motor driven rotor used in centrifugal force and siren disc experiments would be better. The siren disc without color wheel makes a startling demonstration when spun in stroboscopic light. Since the holes are spaced regularly on each circumference, and the circles are of different radii, some holes will appear to move clockwise and others in the opposite direction. Some will not move at all if the speed is carefully controlled. Since all know the apparatus is solid, the demonstration is ideal in science shows for the public.

In discussing the effect, the students should note how the circular holes appear oblong at low projector speeds. Also, placing a chalk radius on the disc should explain much to the student. By variation of the rotor speed alone the student finds that the holes may be stopped at two speeds. It is more difficult to obtain the same effect by variation of the projector.

In class discussions from the demonstration still diagrams seem to be necessary. In quantitative work the student is limited to known source frequencies of silent film, sound film, and frequencies derived from the usual alternating current. The rotor velocity may be obtained from the revolution counter usually mounted on the frame. If the rotor is not available and quantitative results are still desired, many old spring phonographs have such a gauge attached to them. Of course, the modern record player gives three or four speeds.

In integrated physics-mathematics classes investigation of numbers of different moduli may simplify the problem and serve as an application of modern algebraic theory.

The use of audio-visual equipment here shows that the physics instructor may find a free source of material in the discards of that service. The author has an agreement to check all obsolete equipment in the department of his school. The physics teacher has a public relations function to publicize his needs; yet, care must be taken to see that the department remains active and useful, and not become an electro-mechanical grave yard.

It should be stated that a properly controlled commercially constructed stroboscope is best. A motor driven timer for an ionized gas bulb is a good second, and also useful in the spark timed falling body determination of "g". However, the above demonstration is useful where the opening criterion is not otherwise satisfied.

# AN INTERESTING APPLICATION OF TRIGONOMETRY

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*New York City Community College, Brooklyn, New York*

Our teaching of high school mathematics is often enriched by an application of the particular topic being discussed in the physical sciences. In our present technological society this is often sufficient motivation for the majority of students. This is not too difficult as there are numerous applications of even the simplest mathematical concepts in the fields of science, business, and industry, with physics presenting many opportunities for the teacher to bring understandable problems into the third- and fourth-year mathematics classrooms.

When the development of trigonometry is in its embryonic stages the student often visualizes this subject simply as the solution of triangles. Its application to the physical world around him then consists of the determination of unknown distances through the use of known distances and certain ratios. With the introduction of trigonometry of the four quadrants and concepts quite apart from the solution of triangles, the student can understandably become nonplused. However, the applications of general trigonometry in the physical sciences are quite numerous and the alert teacher may wish to present one of them to a class whose enthusiasm for trigonometry may be waning.

The field of electrical engineering presents an interesting problem which should be intelligible to high school students. Most students have some intuitive ideas about magnetism and should have little difficulty in following the argument. Only two new ideas need be presented to the student before an application is shown: first, that the space surrounding the poles of a magnet is filled with a hypothetical "magnetic field" and secondly, that when a conductor cuts through this field an electrical voltage is induced in the conductor. The problem to be discussed is this: it is required to find a quantitative expression for the voltage induced in a conductor rotating in the space between two fixed magnets. This one problem forms the basis for an entire field of study and its solution will be shown to be dependent upon general trigonometry.

Michael Faraday, in 1831, discovered that the voltage induced in a conductor depends upon just two factors: the speed of the conductor perpendicular to the magnetic field, and the strength of the field. In our problem this field is of constant (uniform) strength and hence the voltage induced depends only upon the speed. By speed is meant the velocity perpendicular to the magnetic field. This field can be visualized as parallel straight lines between the two magnets. See Figure 1.

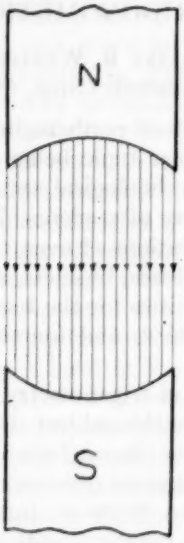


FIG. 1. This drawing shows the conventional representation of the magnetic field between two permanent magnets.

But our problem is to find the voltage induced when a conductor rotates in this field. It is obvious that the conductor will be moving at right angles to the field at certain times and at other times will be moving parallel to the field. When the conductor moves in a direction perpendicular to the field the maximum voltage will be induced and when the motion is parallel to the field no voltage will be induced. At instants between these two extremes the voltage will be some intermediate value depending upon the perpendicular component of velocity. We can resolve this complex motion of the conductor into its two components using trigonometry. See Figure 2.

In this figure the velocity of the conductor is represented by the length $v$ and this velocity is resolved into two components, $a$ and $b$. The component $a$ is the only one of interest because it is at right angles to the magnetic field while $b$ is parallel to the field and has no effect on inducing a voltage. Let $\theta$ be the angle through which the conductor has revolved. Then $\theta$ is also part of triangle $ABV$ such that $\sin \theta = a/v$ and $a = v \sin \theta$. Remembering that the velocity $v$ is constant and that the component $a$ alone determines voltage let us see what happens as the conductor makes one complete rotation in this magnetic field.

1. When $\theta$ is between $0°$ and $90°$, $\sin \theta$ increases and $a$ increases. Voltage rises from zero to some finite maximum value.

FIG. 2. This figure shows the conductor (solid cross-section) moving counterclockwise through the magnetic field as indicated by the dashed line. At some instant it has moved through an angle $\theta$ and the vector $v$, drawn tangentially to the path, is resolved into its two components $a$ and $b$. The component $a$ is at right angles to the field and $b$ is parallel to the field.

2. When $\theta$ is between 90° and 180°, sin $\theta$ decreases and $a$ decreases. Voltage decreases from maximum to zero.

3. When $\theta$ is between 180° and 270°, sin $\theta$ increases and $a$ increases but in an opposite direction. Physically, the voltage increases but in an opposite polarity (sense).

4. When $\theta$ is between 270° and 360°, sin $\theta$ decreases and $a$ decreases. The voltage decreases from its maximum negative sense to zero.

In summary, the voltage induced in all four quadrants of rotation is dependent upon the sine of the angle through which the conductor has moved. When the sine is positive the voltage is of one polarity and when the sine is negative the voltage is of an opposite polarity.

If the voltage induced when $a$ is a maximum (at 90° and 270°) is called $E_{max}$ then we can say that the voltage at any point in the circle of rotation is

$$e = E_{max} \sin \theta$$

where $e$ is the voltage at any instant

$E_{max}$ is the maximum voltage (at 90° and 270°)

and $\theta$ is the angle through which the conductor has moved

This simple trigonometric equation forms the basis for the entire field of alternating current theory in electrical engineering. The design and use of huge power generating stations as well as tiny transistors

is dependent upon this equation. The student who wants to see an application of trigonometry other than the solution of triangles need only look this far. Here we have seen an application of trigonometry in the physical sciences. We have seen a physical quantity (voltage) depend upon the sine function of a general angle. The rotation of a wire (or of a whole coil) in a magnetic field seems far removed from the solution of a triangle. Yet trigonometry played a large part in deriving a quantitative expression for the result of this motion.

Mathematics, as an element of human thought, can stand by itself; it needs no applications. But a teacher must be cognizant of the psychological as well as the logical aspects of learning. And hence this teacher will attempt to present interesting and relevant situations in which mathematics explains the physical sciences. Perhaps our scientific manpower shortage could be erased if the intellectual curiosity of students is sufficiently aroused.

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## GROW RADIOACTIVE POPPIES TO GET "HOT DOPE"

In an effort to trace morphine from its beginning in a plant through the human body, scientists at the University of California at Los Angeles are trying to grow "hot" poppies.

Dr. Edward Leete, assistant professor of chemistry, is investigating the origin of morphine by feeding radioactively tagged compounds to the opium poppy.

If the poppy uses one or more of the radioactive compounds in the synthesis of morphine, a main component of opium, the drug then will become radioactive.

Thus the radioactivity will help detail the manner in which morphine is formed and perhaps give a clue to its function in the plant, which is unknown.

Radioactive morphine, which Dr. Leete hopes to make available, would be a valuable tool to medical science, he points out. By using the "hot" dope, medical scientists could follow its course through the body.

In this manner they could learn more about the drug's beneficent effects in relieving pain or the harmful path that leads to drug addition.

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## UN ASKS FOR RADIATION CHECK IN MILK AND FISH

The United Nations has asked world governments to report how much deadly strontium 90 is finding its way into both milk and fish from nuclear weapons testing fallout.

The request came from the United Nations Scientific Committee on the Effects of Atomic Radiation, which was set up to make a world-wide study of radiation from medical uses, weapons fallout and industrial applications of nuclear energy.

To obtain accurate fallout information, 88 governments have been asked to standardize their measurements of strontium 90. Samples of materials such as milk ash, bone ash and a mixture of fission products, all safe to handle, are being sent from UN headquarters to participating countries.

Laboratories in each country will measure the radioactivity and other characteristics of the samples and send the information back to the Committee.

# VERBAL EXPLANATIONS OF FINANCIAL FORMULAS

R. F. GRAESSER
*University of Arizona, Tucson, Arizona*

Formulas in the mathematics of finance are usually derived algebraically. However, they may often be explained verbally, and such verbal explanations are sometimes quite enlightening. A number of verbal explanations follow.

Mathematics of finance depends on the assumption that money can always be invested productively at some assumed rate of interest $i$ per interest period. The interest earned in any interest period is then converted into principal, or compounded, at the end of each interest period. The interest period will hereafter be referred to simply as the period. The preceding assumption leads to the *principle of equivalence*. According to this principle $P$ payable at any time is equivalent to (or is just as desirable as) $P(1+i)^n$ payable $n$ periods later, or $P(1+i)^{-m}$ payable $m$ periods earlier. This later sum is often written $Pv^m$, where $v$ represents $(1+i)^{-1}$. Of course, $P(1+i)^n$ is also equivalent to $Pv^m$. Equivalent sums may be substituted for one another. If they are evaluated on any chosen date, they are equal, and such a chosen date is called a *comparison date*. For example, the three equivalent sums mentioned, all have the value $P(1+i)^2$ if the comparison date is two periods after $P$ is payable. Their values on that comparison date are, taken in the order in which they are mentioned, $P(1+i)^2$, $P(1+i)^n v^{n-2}$, $Pv^m(1+i)^{m+2}$, all of which reduce to $P(1+i)^2$. Situations such as this are often clarified by diagrams like Figure 1. In Figure 1 the sums are shown along a time axis at the dates upon which they are payable. We now proceed to some verbal explanations using the usual actuarial symbols.

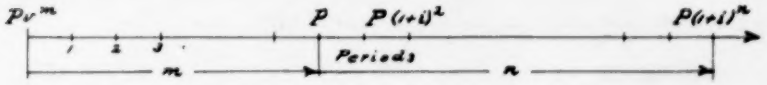



FIG. 1

*1. Present value of a perpetuity of 1 per period, or* $a_{\infty}$. The sum $1/i$ will earn $(1/i)i=1$ in interest at the end of each period from now on, forever and ever. A perpetuity of 1 per period is then equivalent to $1/i$ now. Hence they are equal on any comparison date. If the comparison date is now, the present, we have in symbols, $a_{\infty}=1/i$.

*2. Present value of a perpetuity of 1 paid at the end of each k periods, or* $a_{\infty,k}$. The compound interest earned by 1 in $k$ periods is $(1+i)^k-1$. Hence $1/\{(1+i)^k-1\}$ earns 1 in $k$ periods. Then, by the same argu-

ment as in 1, $1/\{(1+i)^k-1\}$ is the present value of a perpetuity of 1 payable at the end of each $k$ periods, or in symbols, $a_{\infty,k}=1/\{(1+i)^k-1\}$.

*3. Present value of an annuity of 1 per period, or $a_{\overline{n}|}$. First explanation.* $a_{\overline{n}|}$ is equivalent to a perpetuity of 1 minus a perpetuity of 1 starting $n$ periods later. Using the present as the comparison date and equating present values, $a_{\overline{n}|}=1/i-(1/i)v^n=\{1-v^n\}/i$. *Second explanation.* One now is equivalent to an annuity of $i$ per period for $n$ periods plus 1 at the end of $n$ periods. See Figure 2 in which equivalent sets of benefits are indicated above and below the time axis, a practice which will be continued throughout this discussion. Again equating present values of equivalent benefits, $1=ia_{\overline{n}|}+v^n$, from which we have easily the desired formula.

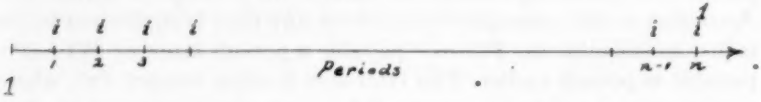



FIG. 2

4. *Amount of an annuity of 1 per period, or $s_{\overline{n}|}$. First explanation.* Using Figure 2, but equating equivalent values at a comparison date at the end of the term of $n$ periods, we have $(1+i)^n=is_{\overline{n}|}+1$. Hence $s_{\overline{n}|}=\{(1+i)^n-1\}/i$. *Second explanation.* With the comparison date still at the end of the term, $s_{\overline{n}|}=a_{\overline{n}|}(1+i)^n$, which leads to the same formula for $s_{\overline{n}|}$.

5. *The formula $a_{\overline{n}|}^{-1}=s_{\overline{n}|}^{-1}+i$.* $a_{\overline{n}|}^{-1}$ is the rent per period of an annuity that 1 will purchase since $a_{\overline{n}|}^{-1}a_{\overline{n}|}=1$. Similarly $s_{\overline{n}|}^{-1}$ is the rent per period of an annuity that will amount to 1. Replacing both one's in Figure 2 by their equivalent annuities, we have Figure 3. Benefits above and below the time axis are equivalent. Hence equating the *periodic rents*, we have the desired formula.

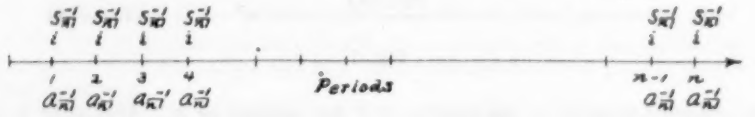



FIG. 3

6. *Amount of an annuity of 1 for $m+n$ periods, or $s_{\overline{m+n}|}$.* Referring to Figure 4, the first $m$ payments of the annuity of 1 are equivalent to $s_{\overline{m}|}$ at the end of $m$ periods and to $(1+i)^n s_{\overline{m}|}$ at the end of $m+n$ periods. The last of $n$ payments are equivalent to $s_{\overline{n}|}$ at the end of $m+n$ periods. Hence, using the end of $m+n$ periods as the comparison date, $s_{\overline{m+n}|}=(1+i)^n s_{\overline{m}|}+s_{\overline{n}|}$.

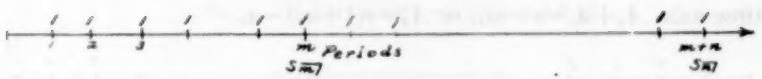



FIG. 4

7. *Present value of an annuity of 1 for m+n periods, or* $a_{\overline{m+n}|}$. The last $n$ payments of 1 are equivalent to $a_{\overline{n}|}$ at the end of $m$ periods or equivalent to $v^m a_{\overline{n}|}$ now. The first $m$ payments of 1 are equivalent to $a_{\overline{m}|}$ now. Using the present as the comparison date, $a_{\overline{m+n}|} = a_{\overline{m}|} + v^m a_{\overline{n}|}$.

8. *Amount and present value of an annuity due of 1 per period, or* $\ddot{s}_{\overline{n}|}$ *and* $\ddot{a}_{\overline{n}|}$. An annuity due is payable at the beginning of each period instead of at the end. As indicated in Figure 5, one at the beginning of each period is equivalent to $1+i$ at the end of each period. Hence $\ddot{s}_{\overline{n}|} = (1+i)s_{\overline{n}|}$ and $\ddot{a}_{\overline{n}|} = (1+i)a_{\overline{n}|}$ using comparison dates first at the end of $n$ periods and then at the present.

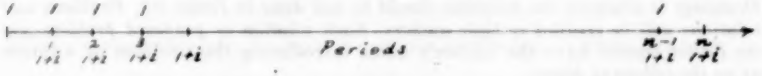



FIG. 5

9. *The premium on a bond, or* $F(r-i)a_{\overline{n}|i}$. Let $r$ be the dividend rate in a bond to be redeemed at par at the end of $n$ dividend periods. Let $i$ be the investment rate, or the value of money, with the interest period coincident with the dividend period. Let $F$ be the face value of the bond. If $i=r$, then the price of the bond is $F$ since the bond pays $Fi$ per period and $F$ on the redemption date. If $r>i$, then the bondholder will receive $Fr>Fi$ at the end of each dividend period. Since $Fi$ is all that is required to pay interest on $F$ at the investment rate, the purchaser of the bond should pay the present value of the excess dividend in addition to the face value $F$ for the bond. This amount, which is added to $F$, is called a premium and equals $F(r-i)a_{\overline{n}|i}$, where $a_{\overline{n}|i}$ indicates that $a_{\overline{n}|}$ is to be evaluated at the rate $i$. If $r=i$, the premium is zero. If $r<i$, the premium is negative and is then called a discount.

10. *The net single premium on an insurance of 1, or* $A_x$. A person aged $x$ is indicated by $(x)$. The present value (or net single premium) of an insurance of 1 payable at the end of the year of death of $(x)$ (the last 1 on the right in Figure 6) is represented by $A_x$. The remaining 1's above the time axis represent an annuity of 1 paid to $(x)$ at the end of each year he survives. Their present value is represented by $a_x$. One at the end of a year is equivalent to $v$ at the beginning of a year. Equating present values of equivalent benefits above and below the

time axis, $A_x+a_x=v+va_x$, or $A_x=v(1+a_x)-a_x$.

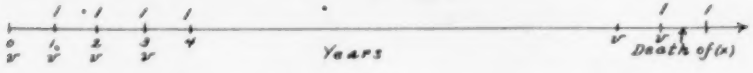



FIG. 6

The foregoing are some examples of verbal explanations of financial formulas. Other examples may be found in textbooks, especially textbooks on actuarial mathematics.

## PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
*San Diego State College, San Diego, Calif.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor* should have the author's name introducing the problem or solution *as on the following pages.*

*The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.*

### SOLUTIONS AND PROBLEMS

**Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.**

**1. Solutions should be in typed form, double spaced.**

**2. Drawings in India ink should be on a separate page from the solution.**

**3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.**

**4. In general when several solutions are correct, the one submitted in the best form will be used.**

### LATE SOLUTIONS

**2572.** *Bridget McArdle, Elizabeth, N. J.*

**2573.** *John Sutton, Elizabeth, N.J.*

**2575.** *Proposal by Leon Bankoff, Los Angeles, Calif.*

Show that the area of a convex quadrilateral is equal to four times that of the triangle determined by the intersection of two opposite non-parallel sides of the quadrilateral and the midpoints of its two internal diagonals.

*Solution by the Proposer*

Let $L$, $M$ be the respective midpoints of the diagonals $BD$, $AC$ of the quadrilateral $ABCD$ and let $P$ denote the intersection of $BA$ and $CD$. Then

$$(\triangle PBD-\triangle BDA)+(\triangle PAC-\triangle ACD)=2(\triangle PAD)$$

Dividing by 2,

$$(\triangle BLP-\triangle BLA)+(\triangle PMC-\triangle DMC)=\triangle PAD$$

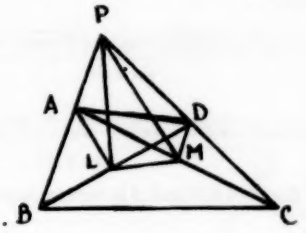
or

$$\triangle ALP+\triangle PMD=\triangle PAD$$

Hence pentagon $PALMD-(\triangle ALP+\triangle PMD)=$ pentagon $PALMD-\triangle PAD$

Therefore

$$\triangle PLM = \text{Quadrilateral } ALMD$$
$$= \tfrac{1}{2} \text{ Quadrilateral } ALCD$$
$$= \tfrac{1}{4} \text{ Quadrilateral } ABCD$$




**2576.** *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.*

If $\beta$ is one half the sum of the medians of a triangle, prove that the area of the triangle is equal to:

$$\frac{4\sqrt{\sigma(\sigma-m_a)(\sigma-m_b)(\sigma-m_c)}}{3}$$

*Solution by the Proposer*

Making use of a theorem in plane geometry, we have:

$$m_a^2=\frac{2b^2+2c^2-a^2}{4}$$

and similar values for $m_b$ and $m_c$. Substitution in Heron's formula will yield the desired result, or the given formula may be reduced to Heron's formula.

A solution was also offered by Brother Felix John, Philadelphia, Pa.

**2577.** No solution has been offered.

**2578.** *Proposed by A. R. Haynes, Tacoma, Wash.*

Given the edges, and their inclinations to one another, of a parallelopiped.

I. Show the surface, $S$, equals $2(bc \sin \alpha+ca \sin \beta+ab \sin \gamma)$

II. Show the volume, $V$, equals

$$abc\sqrt{1-\cos^2\alpha-\cos^2\beta-\cos^2\gamma+2\cos\alpha\cos\beta\cos\gamma}$$

III. Show its diagonal, $D$, equals

$$\sqrt{a^2+b^2+c^2+2bc\cos\alpha+2ca\cos\beta+2ab\cos\gamma}$$

where the edges adjacent to the vertex, $O$, are $a$, $b$, $c$, and the inclinations are $c$ to $b$, $\alpha$; $c$ to $a$, $\beta$; $a$ to $b$, $\gamma$. $D$ is the diagonal from $O$ to the corresponding opposite vertex.

*Solution by the Proposer*

I The areas of the three pairs of faces are:

$$2bc \sin \alpha$$
$$2ca \sin \beta$$
$$2ab \sin \gamma$$

and the area follows.

II. Describe a sphere with center at vertex $O$ cutting edges $a$, $b$, $c$ and diagonal of face $OAEB$ in $a'$, $b'$, $c'$, $e'$ respectively. Drop a perpendicular from vertex $C$ to base $OAEB$. Then $V = ab \sin \gamma \cdot CH = abc \sin \gamma \sin c'e'$. Now spherical triangle $c'e'a'$ has a right angle at $e'$ and by Napier's Rules:

$$\sin c'e' = \cos (\cot \beta) \cdot \cos (\cot c'a'e')$$
$$= \sin \beta \sin (c'a'e'), \; c'e'a' = A'.$$

In spherical triangle $a'b'c'$:

$$\sin A' = \frac{\sqrt{1 - \cos^2 \alpha - \cos^2 \beta - \cos^2 \gamma + 2 \cos \alpha \cos \beta \cos \gamma}}{\sin \beta \sin \gamma}$$

therefore

$$V = abc \cdot \sin \gamma \cdot \sin \beta \cdot \frac{\sqrt{1 - \cos^2 \alpha - \cos^2 \beta - \cos^2 \gamma + 2 \cos \alpha \cos \beta \cos \gamma}}{\sin \beta \sin \gamma}$$

III. $OE$ is diagonal of face $OAEB$ and $d$ is vertex opposite $O$, and $Od = D$, the diagonal. In triangle $OEd$,

$$D^2 = \overline{OE}^2 + \overline{Ed}^2 + 2\overline{OE} \cdot \overline{Ed} \cos COE \tag{1}$$

In triangle, $OBE$,

$$\overline{OE}^2 = a^2 + b^2 + 2ab \cos \gamma \tag{2}$$

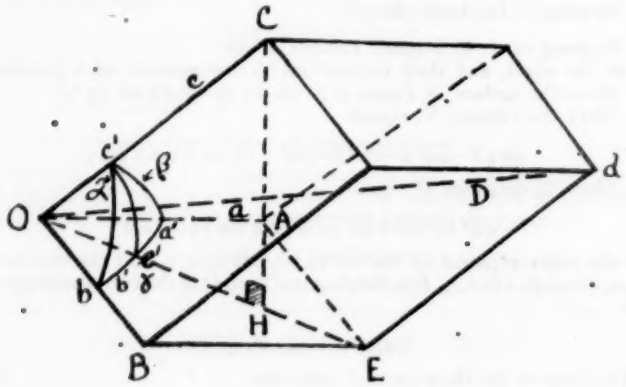
The projections of $\overline{OB}$ and $\overline{BE} = \overline{OA}$ on $OE = \overline{OE}$. Now the projection of $\overline{OB}$ on $\overline{OC}$ is $b \cos \alpha$ and of $\overline{OA}$ on $\overline{OC}$ is a $\cos \beta$. Hence the projection of $\overline{OE}$ on $\overline{OC}$ equals $b \cos \alpha + a \cos \beta$. Since $Ed = OC$,

$$2\overline{OE} \cdot \overline{OC} \cos COE = 2c(\overline{OE} \cos COE)$$
$$= 2bc \cos \alpha + 2ac \cos \beta \tag{3}$$

Substitute (2) and (3) in (1).

$$D = \sqrt{a^2 + b^2 + c^2 + 2bc \cos \alpha + 2ca \cos \beta + 2ab \cos \gamma}$$

The Proposer suggested that a solution of the above problem may be found through the use of Solid Geometry. For such a solution he recommends *Solid Geometry* by C. Smith, Macmillan Co., London, 1897, pp. 28.

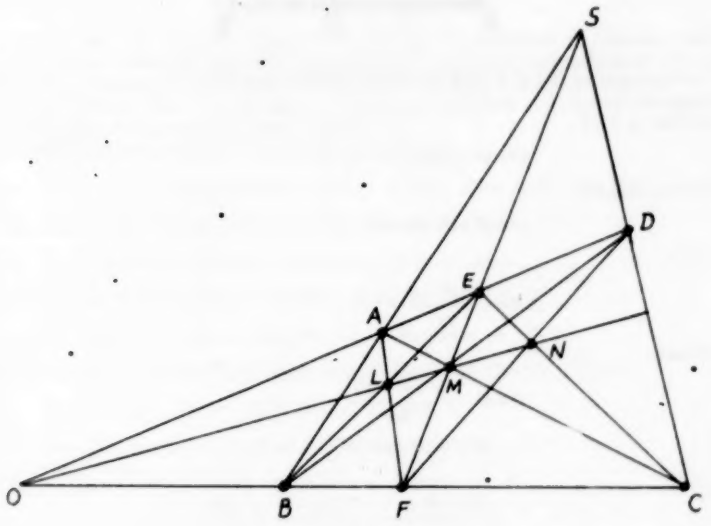


**2579.** *Proposed by Cora Ritter, Montgomery, Alabama.*

There are four trees standing, forming an irregular quadrilateral. How may 5 more trees be planted so that the 9 will form 10 straight rows with 3 trees in each row?

*Solution by Leon Bankoff, Los Angeles, Calif.*

Consider the quadrilateral $ABCD$, with $BA$, $CD$ intersecting at $S$ and $DA$, $CB$ meeting at $O$. Let $M$ denote the intersection of the diagonals $AC$, $BD$. Let $SM$ cut $AD$ at $E$ and $BC$ at $F$. Let $OM$ cut $AF$ at $L$ and $DF$ at $N$.




Then $A, E, D, L, M, N, B, F, C$ represent the locations of the 9 trees, forming the 10 rows $AED$, $LMN$, $BFC$, $AMC$, $BMD$, $EMF$, $BLE$, $ALF$, $ENC$ and $FND$.

Eight collinearities arise by construction. The collinearity of $E$, $L$, $B$ and $E$, $N$, $C$ is established by the fact that $L$ and $N$ lie on $OM$, the axis of homology, and are therefore the intersections of corresponding elements of the triangles $AFD$ and $EBC$, perspective from $S$. (See J. W. Young, Projective Geometry, Open Court Publishing Co., Chicago, 1930, p. 50–51.)

Other solutions are possible. For example, the same configuration applies if the given figure is $ABFE$, $EFCD$, $ALME$, or any other tetrad forming a convex quadrilateral.

A solution was also offered by Walter R. Warne, St. Petersburg, Fla.

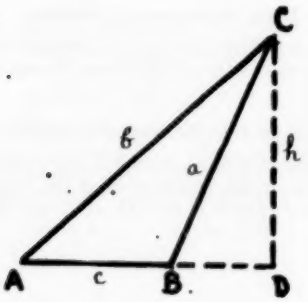
**2580.** *Proposed by J. W. Lindsey, Amarillo, Texas.* (*Especially for students of elementary mathematics.*)

Derive

$$\sqrt{s(s-a)(s-b)(s-c)}$$

for the area of a triangle, where the sides are $a$, $b$, and $c$ and $s$ equals $\frac{1}{2}$ the perimeter.

*Solution by the Proposer*




At least one of the $\measuredangle A$ and $B$ of the $\triangle ABC$ is acute.
Suppose that $\angle A$ is acute.
In the $\triangle ADC$,

$$h^2=b^2-\overline{AD}^2.$$

In the $\triangle ABC$,

$$a^2=b^2+c^2-2c\cdot AD.$$

Then

$$AD=\frac{b^2+c^2-a^2}{2c}.$$

Hence

$$\begin{aligned}h^2&=b^2-\frac{(b^2+c^2-a^2)^2}{4c^2}\\&=\frac{4b^2c^2-(b^2+c^2-a^2)}{4c^2}\\&=\frac{(2bc+b^2+c^2-a^2)(2bc-b^2-c^2+a^2)}{4c^2}\\&=\frac{\left[(b+c)^2-a^2\right]\left[a^2-(b-c)^2\right]}{4c^2}\\&=\frac{(a+b+c)(b+c-a)(a+b-c)(a-b+c)}{4c^2}.\end{aligned}$$

Let

$a+b+c=2s$, where $s$ stands for semiperimeter.

Then

$$b+c-a=a+b+c-2a=2s-2a=2(s-a).$$

Similarly,

$$a+b-c=2(s-c),$$

and

$$a-b+c=2(s-b).$$

Hence

$$h^2=\frac{2s\cdot 2(s-a)\cdot 2(s-b)\cdot 2(s-c)}{4c^2}.$$

Simplifying, and finding the square root, we have

$$h=\frac{2}{c}\sqrt{s(s-a)(s-b)(s-c)}.$$

Hence the area of

$$\triangle ABC=\tfrac{1}{2}ch=\sqrt{s(s-a)(s-b)(s-c)}.$$

This problem was taken from *New Trigonometry*, by Virgil S. Mallory. It is found on page 133, and is No. 12.

## STUDENT HONOR ROLL

**The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.**

**Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.**

**For this issue the Honor Roll appears below.**

**2576.** *Charles E. Chaffey, Trinity College School, Port Hope, Ontario, Canada.*

**2578, 2580.** *John Wells, Plainfield High School, Plainfield, N.J.*

**2580.** *Henry Bolander, Boston Latin School, Boston, Mass.*

**2580.** *Charles Kohler, Cook's Academy, Montour Falls, N. Y.*

**2580.** *George Marsh, Johnson School, No. 9, Romulus, N. Y.*

**2580.** *Sol Rauch, Baron Byng High School, Montreal, Quebec, Canada*

**2580.** *Milton Reese, Elmira High School, Elmira, N. Y.*

**2580.** *Grace Sauls, Rochester East High School, Rochester, N. Y.*

**2580.** *Martha Tobias, Fayette Select School, Fayette, N. Y.*

**2580.** *Antonio Tudeno, Starkey Seminary, Lakemont, N. Y.*

**2580.** *Wilmer Wilson, Ovid High School, Ovid, N. Y.*

**2580.** *Ruth Yerkes, Clearwater High School, Clearwater, Fla.*

## PROBLEMS FOR SOLUTION

**2599.** *Proposed by Brother Felix John, Philadelphia, Pa.*

Solve the equation

$$\frac{x-a}{b}+\frac{x-b}{a}=\frac{b}{x-a}+\frac{a}{x-b}.$$

**2600.** *Proposed by A. R. Haynes, Tacoma, Wash.*

The vertices of triangle $ABC$ are (5, 0), (13, 0), and (0, 43) respectively. The orthocenters of equilateral triangles constructed externally on the sides of triangle $ABC$ are joined to form the triangle $DEF$. Compute the radius of the circumcircle of triangle $DEF$.

**2601.** *Proposed by L. M. Riddle, Exeter, N. H.*

Find the fallacy in this argument:

$$e^{i\theta}=\cos\theta+i\sin\theta$$

$$e^{i\pi}=-1$$

$$e^{2i\pi}=-1$$

$$2i\pi \ln (e) = \ln 1$$

$$2i\pi = 0.$$

**2602.** *Proposed by Cecil B. Read, Wichita, Kansas.*

From the top of a scenic incline of uniform slope the angle of depression of a building on a level plain below is 30°, from a station $\frac{2}{3}$ of the way down the incline, the angle of depression of the same building is 15°. Find the slope of the incline.

**2603.** *Proposed by James Schmerl, Piedmont, Calif.*

In a sphere of radius $r$ what is the area of the base of the spherical triangular pyramid whose three face angles of the polyhedral angle at the center of the sphere are $A$, $B$, $C$?

**2604.** *Proposed by Mary Reegan, Minneapolis, Minn.*

If angles $A$ and $B$ are acute, prove geometrically that

$$\sin A + \sin B = 2 \sin \tfrac{1}{2}(A+B) \cdot \cos \tfrac{1}{2}(A-B).$$

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## BOOKS AND PAMPHLETS RECEIVED

BEHAVIOR OF METALS AT ELEVATED TEMPERATURES, Lectures delivered at Institution of Metallurgists Refresher Course, 1956. Cloth. Pages vii+122. 21.5×13.5 cm. 1957. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $6.00.

CALCULUS WITH ANALYTIC GEOMETRY, by Richard E. Johnson, *Smith College;* and Fred L. Kiokemeister, *Mount Holyoke College.* Cloth. Pages xi+650. 15×23 cm. 1957. Allyn and Bacon, Inc., 41 Mt. Vernon Street, Boston 8, Mass. Price $7.95.

COLLEGE ALGEBRA, by Irwin K. Feinstein and Kenneth H. Murphy, *University of Illinois.* Paper. Pages xi+362. 20.5×12.5 cm. 1957. Littlefield, Adams and Co., 127 Oliver Street, Paterson, N. J. Price $1.75.

CONSTRUCTING AN ASTRONOMICAL TELESCOPE, 2nd Ed., by G. Matthewson. Cloth. Pages xii+100. 12×18.5 cm. 1957. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $3.00.

ELEMENTARY TEACHERS GUIDE TO FREE CURRICULUM MATERIALS, FOURTEENTH ANNUAL EDITION, Edited by Patricia Horkheimer Suttles, *M.B.A.;* Educational Consultant, John Guy Fowlkes, *Ph.D., Professor of Education, University of Wisconsin.* Paper, Pages xv+319. 21×27 cm. 1957. Educators Progress Service, Randolph, Wis. Price $5.50.

PLANE GEOMETRY, by John F. Schacht and Roderick C. McLennan. Cloth. Pages xvi+494. 16×23.5 cm. 1957. Henry Holt and Company, 383 Madison Ave., New York 17, N. Y. Price $3.84.

PRINCIPLES OF PHYSICAL SCIENCE, by Francis T. Bonner, *Arthur D. Little, Inc.;* and Melba Phillips, *Washington University.* Cloth. Pages xvi+736. 15×23 cm. 1957. Addison-Wesley Publishing Co., Inc., Reading, Mass. Price $7.50.

TEACHER'S GUIDE AND ANSWERS FOR THE SCRIBNER ARITHMETIC, BOOK 6, by Richard Madden, Leslie S. Beatty, and William A. Gager. Paper, 189 pages. 23×30.5 cm. 1957. Charles Scribner's Sons, 597 Fifth Avenue, New York 17, N. Y. Price $2.28.

THE BASIC CONCEPTS OF MATHEMATICS, A COMPANION TO CURRENT TEXTBOOKS ON ALGEBRA AND ANALYTIC GEOMETRY, Part I, Algebra, by Karl Men-

ger. *Professor of Mathematics, Illinois Institute of Technology.* Paper. Pages vii+93. 14×22 cm. 1957. The Bookstore, Illinois Institute of Technology, Chicago 16, Ill.

VERTEBRATES OF THE UNITED STATES, by W. Frank Blair, *Professor of Zoology, University of Texas;* Albert P. Blair, *Professor of Zoology, University of Tulsa;* Pierce Brodkorb, *Professor of Biological Sciences, University of Florida;* Fred R. Cagle, *Professor of Zoology, Tulane University;* and George A. Moore, *Professor of Zoology, Oklahoma A and M College.* Cloth. Pages ix+819, 16×23.5 cm. 1957. McGraw-Hill Book Co., Inc., 330 W. 42nd Street, New York 36, N. Y. Price $12.00.

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## BOOK REVIEWS

INTRODUCTORY COLLEGE MATHEMATICS by Robert H. Wagner, *Professor of Mathematics University of Massachusetts.* Cloth. Pages xiv+430. 17×23.7 cm. 1957. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y. Price $5.50.

This text covers the number system, equations and inequalities, the function concept, much of the usual material of college algebra, trigonometry, and analytic geometry, a brief introduction to calculus; a brief treatment of interest and annuities, and of statistics and probability. In fact, one wonders if some of the topics were not included with the idea of making more sales, rather than with the purpose of achieving a unified collection of material.

Some topics appealed to this reviewer, for example, the treatment of equations and inequalities in parallel columns, under the general heading of linear (or quadratic) relations. Alternative definitions for conics utilize distances from intersecting (or parallel) lines; this enables the student to discuss the general second degree equation without rotating the axes. In introducing the discussion of the equation of a locus the author makes a very nice point in showing the necessity of omitting certain points (this avoids an error frequently found in other texts). In defining the ranges for the inverse trigonometric functions (the term *principal value* is not used) it is carefully pointed out that alternative definitions may be encountered.

On the other hand, some points seemed unsatisfactory. It seems perhaps a matter of opinion that in simplifying expressions involving more than one set of signs of grouping "it is usually easier to start from the inside. . . ." On page 13 a proof that the number of primes is infinite seems to imply unique factorization, which has not been proved. The statement that any positive number has a common logarithm which is the sum of an integer and a positive proper fraction seems to be hard to verify in the case of any power of ten. The introduction of synthetic division seems to be purely a mechanical rule, with a verification that the process works. A good student might well wonder how anyone ever developed the rule. A matter of opinion is again involved in the statement that the radian is "a less common unit [than the degree] for measuring angles." Again in the field of trigonometry the reviewer objects to the statement that $\sin^{-1}(\ )$ represents an angle, while arcsin $(\cdot)$ represents a number. On page 199 one finds a series of equalities $\sin 720°/\pi = \sin 229.12° = \sin 229°7' = -\sin 49°7' = -0.7560$ without any qualification that some of these are approximate relations. On page 183, in showing the proof of a trigonometric identity, the text states, ". . . the trick is to study the given expression and from this study chose a way of starting which might lead to success." The reviewer personally objects to this method of analysis being called a "trick," perhaps indicating some knowledge of magic is required. On page 205, after plotting twelve points (monthly mean temperatures for the twelve months) the author presents (with no evidence of source) a compound trigonometric function, and a table of values for this function closely approximating the given values. The comment is made, "Such similarity is definitely not a

coincidence." What proof is there that this is not coincidence? If the function was determined so it approximated the given points, why not use a polynomial of the eleventh degree, which could be made to pass exactly through the points?

In defining polar coordinates, we find, ". . . $r$ denotes the directed distance from the pole to $P$, and $\theta$ denotes an angle from the polar axis to the direction from the pole to $P$." The concept of angle *from an axis to a direction* seems unusual, to say the least. On the next page we find, ". . . the point with coordinates $(-3,60°)$ is found by first choosing the direction 60° and then going $-3$ units in this direction." Technically this may agree with the definition, but it seems awkward.

The supply of problems seems adequate, somewhat short in a few places. Tables are adequate for the purposes of the text. Answers are provided to odd-numbered exercises. Definitely this is not the poorest book on the market; neither would this reviewer call it the best. Since opinions vary, it certainly merits inspection.

CECIL B. READ
*University of Wichita*
*Wichita, Kansas*

INTRODUCTION TO FINITE MATHEMATICS, by John G. Kemeny, J. Laurie Snell and Gerald L. Thompson, *Department of Mathematics, Dartmouth College.* Cloth. Pages xi+279. 15×23 cm. 1956. Prentice-Hall, Inc., 70 Fifth Avenue. New York 11, N. Y. Price $5.50.

In recent years there has been increasing agitation for a new type of course in freshman college mathematics, either one which could be taken in lieu of the traditional courses, or which could accompany such courses. This text is largely the result of the introduction of a course of this type at Dartmouth College, which has as one objective the introduction of some concepts in modern mathematics. Applications tend to be chosen from the behavioral or the biological sciences, rather than the physical sciences. The applications, particularly in the last chapter, seem definitely non-trivial. In the development of the material, the authors decided to restrict the material to finite problems, that is, to exclude infinite sets, limiting processes, etc.

To what extent the classroom teacher will believe that the authors have been successful in their objective will no doubt vary with the teacher, his teaching situation, and certainly with his students. While the authors state that the only prerequisite for this book is the mathematical maturity obtained from two and a half or more years of high school mathematics, the reviewer feels he has encountered students with technically this much credit, who would be lost within the first seventy pages (the high school mathematics might, for example, include general mathematics, vocational arithmetic, and a second unit of general mathematics).

Certainly the treatment is far from traditional, and in may places seemed unusually well presented. One should not expect the traditional algebra, trigonometry, and analytics; no brief review can give the unusual flavor of this text. A brief summary may indicate the line of development. The first chapter, entitled "Compound Statements" might have been called elementary mathematical logic. Rather extensive use is made of truth tables and tree diagrams, there is a brief treatment of switching circuits. Problems seem ample, and interesting; certainly several are non-trivial.

The second chapter deals with sets and subsets; Venn diagrams, and an introduction to Boolean algebra are among the topics encountered. In Chapter III, Partitions and Counting, the introduction is in terms of partitions of a set. Permutations are introduced, as well as the Pascal triangle and the binomial and multinomial theorem. (The term "combinations" is not used, nor is it found in the index.) Chapter IV introduces probability theory, the first introduction being that of assigning a probability measure to the subsets of a possibility set. Included are such topics as Bayes theorem, stochastic processes, problems of decision, the law of large numbers, Markov chains. Chapter V introduces vectors and

matrices, with many illustrations of their application to fields other than physics or pure mathematics. Chapter VI is devoted to an introduction to linear programming and the theory of games.

Probably sufficient indication has been given of the manner in which this work differs from the usual text. If there is any possibility that your institution is contemplating introducing a non-traditional course, this text must be considered. Even if this is not the case, the reviewer would suggest the book as a valuable and readable introduction to some of the concepts of modern mathematics. It will be of use to the individual teacher, or for reference in a school library. Many high school students will enjoy portions of the book, even if they are unable or do not care to read it from cover to cover.

CECIL B. READ

ARITHMETIC FOR ENGINEERS, *Fifth Edition*, by Chas. B. Clapham, *formerly lecturer and demonstrator in the Mechanical Engineering Departments at the Goldsmiths' College, New Cross, S.E., Finsbury Technical College, and Candiff Municipal Technical College*, Cloth. Pages xiii+540. 14×22 cm. 1954. Chapman & Hall Ltd., London, England. Price 21s.

This book was written for the student with "average ability and for those engaged in home study." Multiple illustrations—pictoral and problem examples—fill the book. It includes elementary topics through trigonometry. The content of the text can best be indicated by the eleven chapter titles; Vulgar Fractions, Decimal Fractions, Symbols and Their Uses, Simple Equations, Transposition of Formulae, Use of Logarithms, Mensuration—Lengths and Areas, Mensuration—Volumes and Surface Areas, Curves or Graphs, The Slide Rule, and Trigonometry.

A great deal of effort has been placed on illustrative exercises. There is a large number and virtually all represent practical situations of engineering. Forty-two additional harder problems are included in the back of the book.

A great deal of effort is also placed upon keeping the cost of the book to a minimum. Reproduction has been accomplished by the photo-offset process. Additions to the former edition have been placed in the back of the book. Notes and extensions for various parts are also written in the back of the book.

The appendix includes a chapter on Verniers and Micrometers. Also included in the back are a 4-place logarithm table, a 4-place antilogarithm table; a 4-place trigonometry table which also includes radian equivalents and length of a chord of a given central angle. A section of notes on simultaneous simple equation involving two unknowns is also included.

The book must be classified as classic in its field. Publication has continued for over forty years in the various editions. Some criticism may be placed in the printing process but a purpose of minimum cost was achieved and may well be worth the price.

RALPH W. JOHNSON
*Lyons Twp. High School*
*LaGrange, Illinois*

DIAGNOSIS AND REMEDIAL TEACHING, A Guide to Practice in Elementary and Secondary Schools, by Glenn Myers Blair, *Ph.D., Professor of Educational Phychology, University of Illinois*. Cloth. Pages xvi+409. 13.5×21 cm. 1956. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $5.00.

The better teachers are disturbed when their students fail. Fortunate is that school if these teachers are concerned not alone for *who* fails but *why* they fail and *what* to do. For those, so minded, Blair's Diagnosis and Remedial Teaching has help.

After an introductory chapter there follow those addressed to: identification; diagnosis and remedial treatment. More specific attention to grade levels is found in chapters focussed on: elementary; junior high school and senior high school student deficiency needs. Major space, Part I, with 200 of the total 409 pages, is

given to remedial reading. However, a chapter each is devoted to remedial teaching for: arithmetic, spelling, hand writing and fundamentals of English. Three other chapters attend to: reading practice exercises; case studies and preparing for remedial teaching.

Foot-notes and abundant after-chapter "references for further study"; twenty-five tables; twenty figures, and sixteen photo-plates add to the book's exposition and make it a resource aid and directive for further research. Its offerings are rendered quickly accessible by aid of an outline-type of table of contents and a fourteen page double-columned index.

This book is an amplified, re-edited version of a previous publication. It is the product of the thinking of a competent scholar. Yet it is so phrased that it is readily followed by the class-room teacher. While identification and diagnosis receive proper attention the burden of emphasis goes to remedial procedures. Especial attention is given to subject deficiencies of high school students. However, teachers of elementary, even down to the third grade, level will find rewarding counsel in its pages.

The book will also offer much to the administrator who is planning a remedial program for his school system. The college teacher scheduled for a course on remedial teaching might well consider this the text for such an offering.

MRS. JESSIE JONES
B. CLIFFORD HENDRICKS
*Longview, Washington*

THE OSCILLOSCOPE AT WORK. by A. Haas and R. W. Hallows, *M.A. Camtab., M.I.E.E.* Cloth. Pages 171. 13.5×21.5 cm. 156. Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $10.00.

Roentgen used cathode rays to incite the first X-rays to be witnessed by man. He presently found their energy to be that of translation rather than vibration. However, he probably never suspected them capable of revealing the chacter of the electrical energy that may be used in their control. The cathode-ray oscilloscope is an instrument that adds that dimension to their use.

There are other than beta-ray oscilloscopes but the book under review restricts its attention to the cathode-ray tube exclusively. Its offering is in eleven chapters. While, as the title suggests, chief attention is to what the instrument *can do*, chapters on: General Characteristics, Operating Troubles, and Improvements and Addition are supplements to those detailing its work services. The *instrument at work* is presented in: Investigating Electrical Magnitudes; study of: Audio-frequency Amplifiers; Radio-frequency Amplifiers; Oscillators; Rectifiers and Detectors; Modulators; Phase-changing and Wave-shaping Circuits and Television Receivers.

The French edition by A. Haas, was found by translator R. W. Hallows, to need much modification and supplementation for effective service in an English edition. So the volume, here reviewed, is much more than a translation; Hallows is quite properly listed as its co-author.

This is a technical treatise. Both its price and its language restrict it to a limited reader appeal. Certainly the research worker in the field of electronics and the technician who services appliances in that area will find here many suggestions to meet their needs. Aiding such use the many diagrams and oscillograms are all provided with helpful explanations. A three and one-half paged double columned index greatly facilitates such use. No bibliography and very few foot-note references are given.

B. CLIFFORD HENDRICKS,
*William Woods College,*
*Fulton, Missouri*

AUTOMATION, ITS PURPOSE AND FUTURE by Magnus Pyke, *B.Sc., Ph.D., F.R.I.C. and F.R.S.E.* Cloth. 191 pages. 13×21 cm. 1957. Philosophical Library, Inc., 15 E. 40th Street, New York 16. N. Y. Price $10.00.

Is automation the precursor of a second industrial revolution? A first chapter of this book briefly probes that assumption under the heading: Industrial Work, New Style. The author attributes the first industrial revolution to mechanization. If this is a second, it comes from automation. The first developed machines to displace physical brawn. Is this second bringing relief from mental effort by means of the electronic computer?

The second chapter, The Electronic Computer, attempts a description of it, the basic unit of automation. However, he makes a parade of its accomplishments much more impressive than his exposition of its principles of operation are enlightening.

The emphasis of chapters three to eleven is upon the applications of automation in different fields. Engineering, chemistry, petroleum, accounting, transportation, food and catering, missiles and even the translation of languages are considered, each with a chapter.

Under the caption, How Soon? an estimate of the probable rate of automation's entry into British (our author is a Scot) industry and other fields is attempted. He catalogues a number of hindrances, many of them peculiarly British, which may slow down its adoption.

A last chapter, Life Automatic, considers what automation may do, not so much to the economy but, to the standards and motivations of the peoples it serves. Will more lesisure provide time to reassess the elements of "the good life" or will such inactivity plague its dromes with boredom and frustration? The author submits evidence in favor of the first of those two alternatives. It is interesting to note he finds that evidence in the trends of leisure-time use in the United States.

*Automation, Its Purpose and Future* will attract readers of varied interests. It will probably not be read in its entirety by any given reader but rather scanned for items of that reader's concern. Once read it is likely to be re-scanned for help in reassessing this "integrator-of-unit-operations" varied possibilities. Unfortunately no index and scarcely more than a skeleton table of contents give little encouragement to this latter use.

The authors leaves little doubt but that automation will increase production but gives scant concern to a decreased cost of that produced. Is the price of his book (five cents per page) a subtle index of what to expect in that connection?

B. CLIFFORD HENDRICKS

FUNDAMENTALS OF PHYSICS, Third Edition, by Henry Semat, Ph.D., *Professor of Physics, the City College of New York*. Cloth. Pages xii+914. 14.5×23 cm. 1957. Rinehart and Company, Inc., 232 Madison Avenue, New York 16, N. Y. Price $8.00.

Fortunately this third edition of *Fundamentals of Physics* by Henry Semat is not a general overhauling of the revised edition. It was not necessary. Rather there are careful modifications and additions in the written material, in drawings, in derivations, in completely worked out examples and in applications that should make introductory college physics clearer to the user than previously.

The order of presentation is standard with sections on mechanics, heat, wave motion and sound, electricity and magnetism, light, and atomics and nucleonics. Units generally accepted as appropriate are used in each section. The author is not afraid to use as much mathematics, within the limitations of algebra and trigonometry, as is necessary to discuss topics correctly in detail. A good example is the analytical method of vector addition. Mathematical derivations are usually included to help make clear the origin of many equations given. An excellent example is found in the section on electromagnetism where, with the aid of the expression for the magnetic field from a small current element, the derivation of the magnetic field from a circuit is understood readily.

Often problems are presented in the body of the text with explicit solutions. I believe the students appreciate too, the many applications of fundamental principles to instruments and devices frequently used in laboratories. A few

specific examples are the diffusion pump, heat engines, primary and storage cells, alternating current devices, elements of radio, and the compound microscope. A question section and a revised problem list appear at the end of each chapter.

I have the feeling that students will get from this textbook a good knowledge about experimental facts and present theories, but not much understanding about the ideas for experiments and for theories. The latter are important too. The use of boxes around a large number of subsidiary equations, thus stressing their apparent importance, I consider to be a small disadvantage in this book. I believe too, that the introduction to a few concepts is so brief as to make their initial understanding difficult for students.

I find more material available in this book than I could discuss in a one year course, and very little is lacking that I would want to include. This is an excellent textbook for the usual as well as the exceptional student.

EARL FRIESEN,
*Assistant Professor of Physics*
*Indiana University*
*Bloomington, Indiana*

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## SCIENTIFIC CHEMISTRY EXPERIMENTS ADDED TO ASSOCIATION'S PROGRAM

A program to help make senior high-school chemistry laboratory experience more stimulating is now being offered by the Manufacturing Chemists' Association on behalf of the chemical industry. Last year the Association initiated its new work in the education field through the establishment of a program for teachers and students of General Science at the Junior High-School level. The General Science program, used in more than 5,500 schools in 1956–57, is being continued.

The chemistry program, consisting of a series of unusual "open-ended" experiments, was developed in consultation with leading educators: Keith Johnson, Science Supervisor, Public Schools, Washington, D. C.; Morris Meister, Principal, Bronx High School of Science, New York, New York; Elbert C. Weaver, Chemistry Instructor, Phillips Academy, Andover, Massachusetts (currently, MCA's Senior Education Adviser, while on stabbatical leave); and Elwood Winters, Professor of Science Education, New York University, New York City, New York. Their proposals were reviewed and approved by a group of chemistry teachers. Selected experiments were then prepared by individual teachers and pilot-tested in representative schools prior to printing.

Of the 30 scientific "open-ended" experiments scheduled for release to schools, about a dozen are currently available, with the remainder to be published during the school year. Students undertaking such experiments will find they cannot anticipate the answers; instead, they must pose questions to nature and discover the results for themselves. Each experiment is tied into real life situations under the heading, "Practical Applications."

Separate instructions for the teacher are provided with each experiment. Suggestions are made about how the experiment may be used, and about ways of performing it; typical results of a try-out are also given. Materials used are those commonly found in high-school laboratories.

The Association offers, without charge, to each school in which chemistry is taught: 30 Student Guide Sheets and One Teacher Information Sheet for each experiment. Teachers wishing to duplicate the experiments for use in their own classes, but not for sale, may do so.

Descriptive folder for either the Chemistry or General Science program may be obtained from Dr. William E. Chace, Director of Education, Manufacturing Chemists' Association, Inc., 1625 Eye Street, N. W. Washington, D. C. An Order Form will be sent with each folder.

## A SUGGESTION FOR MEMORIZATION

Various devices have been suggested for the memorization of certain numbers which appear in mathematics. To remember *pi*, think of the expression, "See, I have a number!" The number of letters in each word gives the sequence of digits 3.1416. If more accuracy is required, you may use

"See, I have a rhyme assisting
My feeble brain its tasks sometime re-
sisting."

One student remembers $\sqrt{3}$ from 1732, the year of George Washington's birth. However, it is probably expecting too great a knowledge of history to remember $\sqrt{2}$ as fifteen years after the abdication of Richard II of England (1399+15 = 1414).—C. B. READ, *University of Wichita.*

---

## NEW NYLONS WILL BE MADE FROM SUGAR

New nylon plastics that have unusual properties and are expected to cost less than the present product will be made from sugar.

It will be possible to "tailor" the properties of the new nylons, or polyamides as chemists call them, to make everything from sheer stockings to ball bearings.

The starting compound in the production of the new nylons is 2-methyl-piperazine, prepared by reacting sugar with ammonia and hydrogen under pressure.

---

## POLIO IMMUNITY INCREASING EVEN WITHOUT SALK VACCINE

Even without Salk shots, people are naturally getting more and more immune to polio, Dr. Robert L. Vought, Bristol Laboratories, Inc., Syracuse, N.Y., and Dr. Morris Greenberg, New York City Department of Health, reported in the *Journal of the American Medical Association.*

Natural immunization against polio occurs when the virus is spread from the gastrointestinal or respiratory tract of either patients or carriers to other people. These people, in turn, become carriers and usually develop immunity without developing active cases of the disease.

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## "DRY PHOTOGRAPHY" AND FILMS FOR NIGHT USE AMONG MILITARY NEEDS SEEN BY ARMY GENERAL

High speed films for military photography at night and a completely dry photographic process for battlefield use were set forth as technical goals for research science by an Army general speaking to members of the Society of Photographic Scientists and Engineers at their 1957 Annual Conference.

Brig. Gen. Earle F. Cook, commanding officer, Army Signal Engineering Laboratories, Fort Monmouth, N. J., told the scientists that photography is the most advanced sensory technique available to the military for gathering intelligence information in combat surveillance.

He cited the advantages of photography in providing a permanent record for expert examination, high resolution for detection of targets, and comparatively light and compact equipment.

## TEACHING PHYSICS BY TELEFILM

The critical shortage of science teachers in the nation's schools and the growing need for persons trained in science have prompted the testing of a unique method for teaching high school physics by telefilm, under a $104,000 grant accepted by the University of Wisconsin Board of Regents.

The Fund for the Advancement of Education established by the Ford Foundaawarded the grant to the University and its Extension Division to conduct a "pilot study" in about 70 Wisconsin communities of part of a complete film course in high school physics. It is produced on 16-mm. color telefilm by Encyclopaedia Britannica Films, Inc.

The course consists of 170 films, but the University will test only 81 of them. However, 81 films are expected to provide a valid test of the entire survey.

A telefilm is a motion picture filmed at the same time a television show is being performed. It is different from a kinescope, which is a facsimile of a television show.

The films, which cover about two semesters work, will be tested throughout the next school year, starting in September.

---

## ANTIBIOTICS FOUND TO BE BEST CANCER-SEEKING DRUGS

Three antibiotics have been found to seek out cancers better than any other known drugs.

The antibiotics themselves will not cure cancer, but the big hope is that they can be used as carriers for the drugs that will.

Here is how they would work:

A known anti-cancer drug with the power to kill cancerous tissue would be combined with the antibiotic and the combination would be injected into the body.

The antibiotic would act like a freight train, carrying the drug right to the spot where it would do the most good, and keeping it there long enough to kill the cancer.

---

## SECOND LARGEST TELESCOPE WILL SCAN SKY SOON

The great 120-inch telescope here at the University of California's Lick Observatory, ten years in the making, may join the 200-inch Palomar sky-searcher before the end of this year.

The mirror is now undergoing its final, delicate stages of polishing and figuring, which may be completed within a month.

Then, after the mirror is aluminized, auxiliary control equipment installed and tests made, the world's second biggest "eye" will be ready to photograph stellar objects more than a billion light years in space.

---

## NEW STEEL WILL PERMIT FLIGHT AT 2,700 MILES PER HOUR

Airplanes and missiles will be able to travel up to 2,700 miles per hour without suffering heat and friction damage to structural materials thanks to a new steel.

Major structural problems of flight at four times the speed of sound can be overcome by the use of new lightweight, ultra-high strength stainless steel developed by Armco Steel Corporation, Middletown, Ohio. The inexpensive steel PH 15-7 Mo, can withstand air friction heat of 1,000 degrees Fahrenheit.

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## AURORAS OCCUR IN ARCTIC AND ANTARCTIC AT SAME TIME

Auroras, the dancing color patterns that sometimes light up the night sky, occur in the Arctic and Antarctic simultaneously.

# Preparation of Manuscripts for Publication in School Science and Mathematics

MANY articles come to our editorial office before they have been put in condition for our use and hence must be rejected. The spelling, punctuation, sentence structure, and all mechanics of the manuscript should be correct before it is submitted. Do not count on making such corrections when you receive the galley proof. All changes in proof mean extra expense. This journal is not endowed and all expenses must be paid out of receipts from subscriptions and advertising. It is a cooperative enterprise. Make your original manuscript exactly right and perfectly clear.

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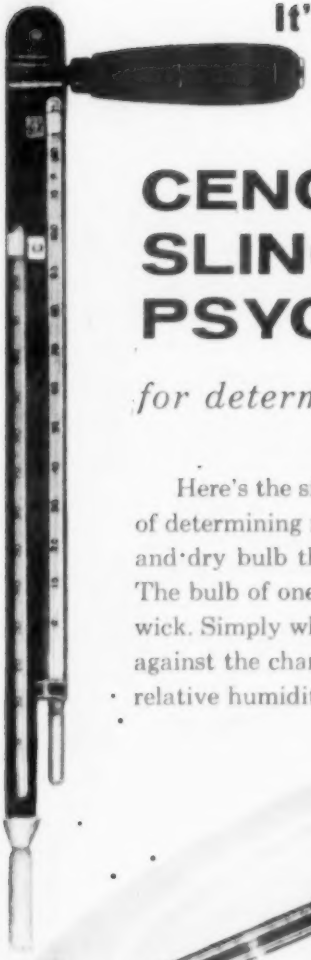

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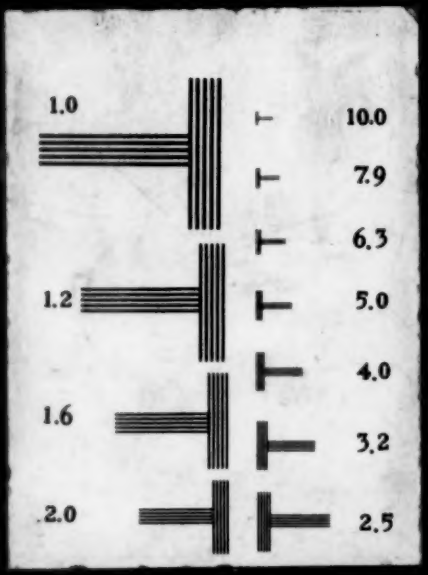
# RESOLUTION CHART




100 MILLIMETERS

**INSTRUCTIONS** Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and 100/20 = 5.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and 7.9 x 5 = 39.5 lines per millimeter recorded satisfactorily. 10.0 x 5 = 50 lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.